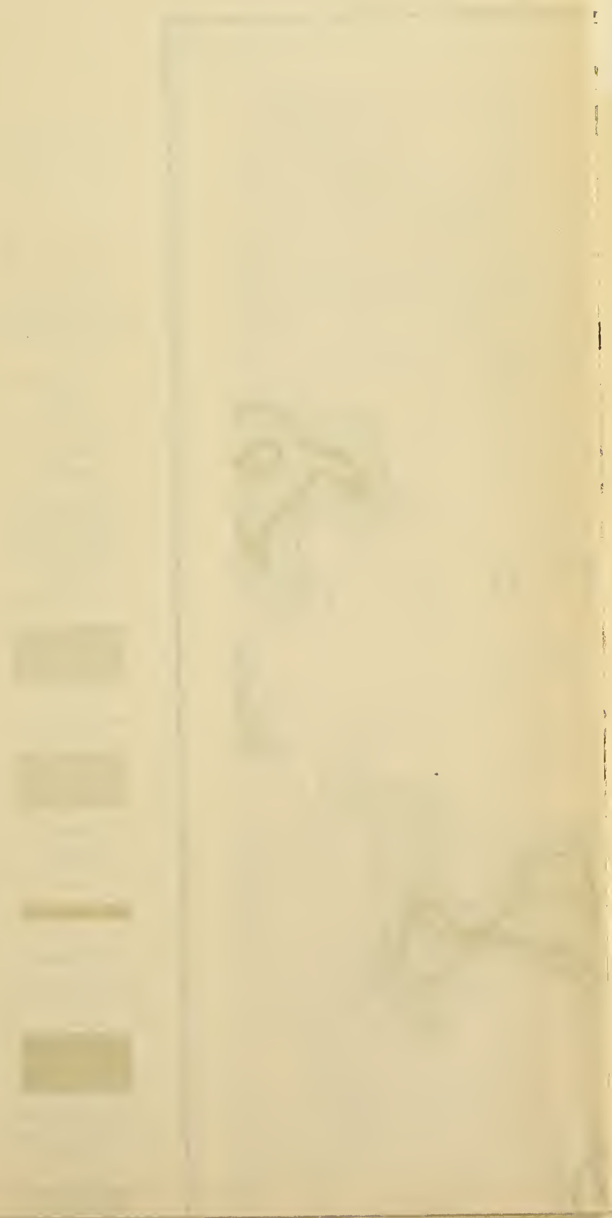
GEOLOGY 6

Topographic map of Little Falls quadrangle

Geologic map of Little Falls quadrangle

PALEONTOLOGY 10

Geologic map of Salamanca quadrangle



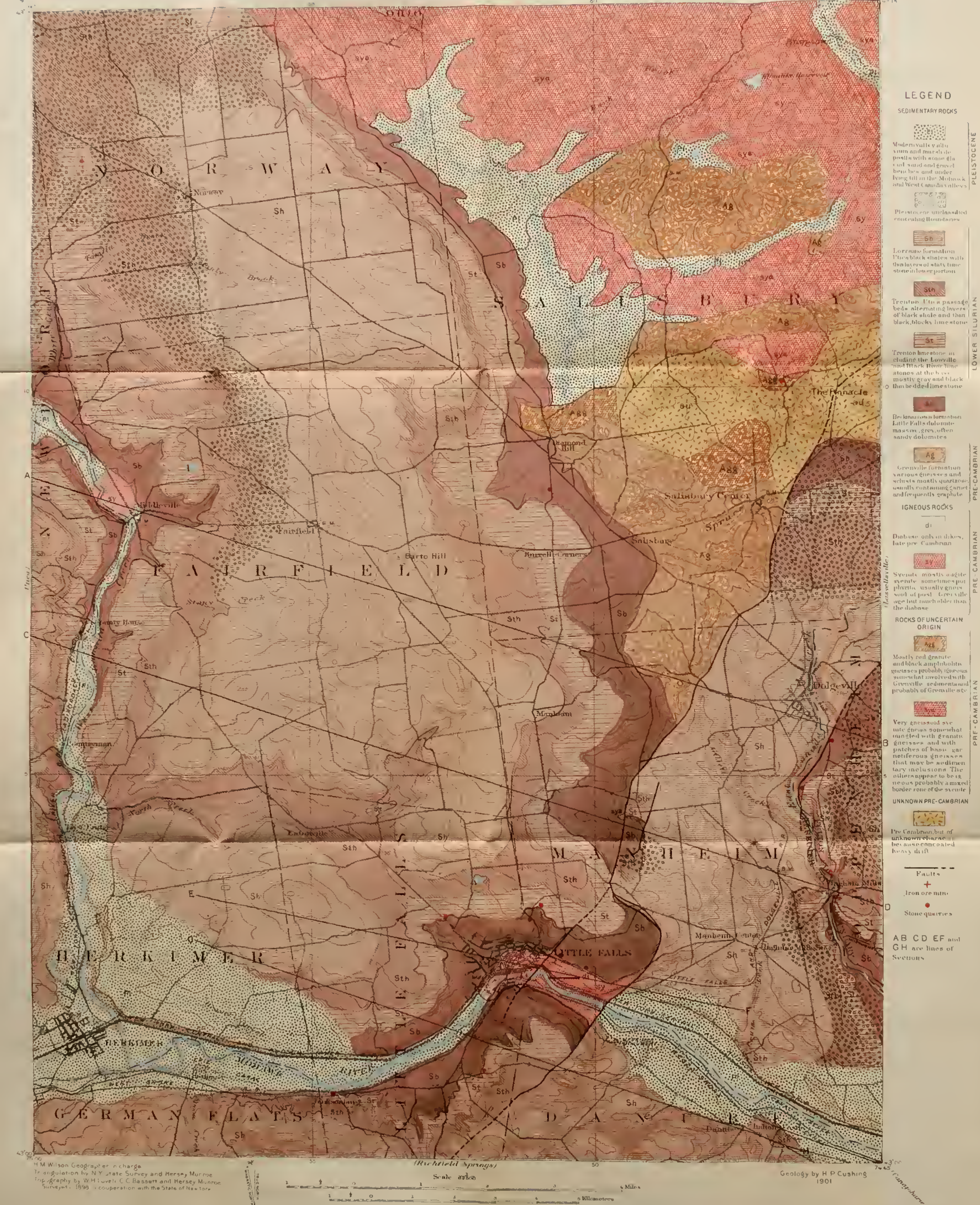
CATION DEPARTMENT

STATE MUSEUM

SALAMANCA QUADRANGLE
REP PALEONTOLOGIST 190

UNIVERSITY OF THE STATE OF NEW YORK
STATE MUSEUM

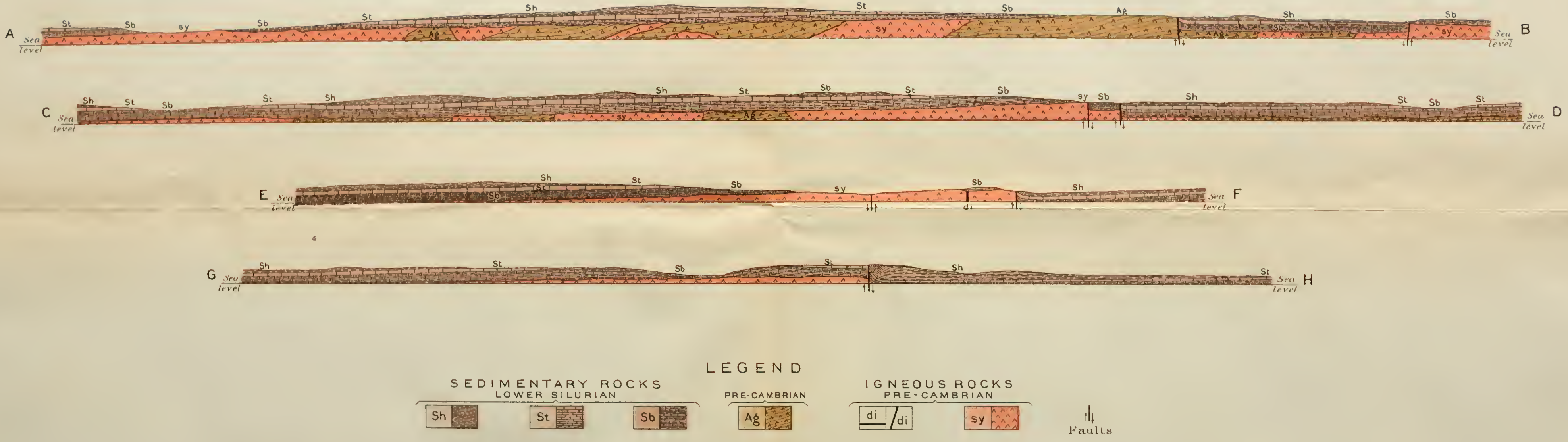
BULLETIN 77
LITTLE FALLS QUADRANGLE



UNIVERSITY OF THE STATE OF NEW YORK

STATE MUSEUM

TOPOGRAPHY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LOWER SILURIAN
PRE-CAMBRIAN
IGNEOUS ROCKS
PRE-CAMBRIAN
Faults

University of the State of New York

NEW YORK STATE MUSEUM

57th ANNUAL REPORT

1903

VOL. 1

57th REPORT OF THE DIRECTOR AND 23d OF THE STATE GEOLOGIST 1903

AND

APPENDIXES 1-5

TRANSMITTED TO THE LEGISLATURE JAN. 6, 1904, BY THE REGENTS OF THE UNIVERSITY

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1905

University of the State of New York

REGENTS 1903

With years of election

1892 William Croswell Doane D.D. LL.D. *Chancellor*, Albany
1878 Whitelaw Reid M.A. LL.D. *Vice Chancellor* New York
1877 Chauncey M. Depew LL.D. - - - - New York
1[illegible] Charles E. Fitch LL.B. M.A. L.H.D. - - Rochester
1[illegible] William H. Watson M.A. M.D. LL.D. - Utica
1881 Henry E. Turner LL.D. - - - - - Lowville
1883 St Clair McKelway M.A. L.H.D. LL.D. D.C.L. Brooklyn
1885 Daniel Beach Ph.D. LL.D. - - - - Watkins
1890 Pliny T. Sexton LL.D. - - - - - Palmyra
1890 T. Guilford Smith M.A. C.E. LL.D. - - Buffalo
1893 Lewis A. Stimson B.A. LL.D. M.D - - - New York
1895 Albert Vander Veer M.A. Ph.D. M.D. - Albany
1895 Charles R. Skinner M.A. LL.D.
Superintendent of Public Instruction, ex officio
1897 Chester S. Lord M.A. LL.D. - - - - Brooklyn
1899 Thomas A. Hendrick M.A. LL.D. - - - Rochester
1901 Benjamin B. Odell jr LL.D. Governor, ex officio
1901 Robert C. Pruyn M.A. - - - - - Albany
1902 William Nottingham M.A. Ph.D. LL.D. - Syracuse
1903 Frank W. Higgins Lieutenant Governor, ex officio
1903 John F. O'Brien Secretary of State, ex officio
1903 Charles A. Gardiner LL.B. M.A. Ph.D. LL.D. New York
1903 Charles S. Francis B.S. - - - - - Troy
One vacancy

SECRETARY

Elected by Regents

1900 James Russell Parsons jr M.A. LL.D.

STATE MUSEUM COMMITTEE 1903

Regent T. Guilford Smith *Chairman*
Regent C. S. Francis, Superintendent of Public Instruction

DIRECTORS OF DEPARTMENTS

1888 Melvil Dewey M.A. LL.D.
State Library and Home Education
1890 James Russell Parsons jr M.A. LL.D.
Administrative, College and High School Dep'ts
1890 Frederick J. H. Merrill Ph.D. *State Museum*

STATE MUSEUM STAFF YEAR ENDING SEP. 30, 1903

Administration and Geology

FREDERICK J. H. MERRILL Ph.D. (Columbia)
Director and state geologist

HENRY H. HINDSHAW B.Sc. (Chicago College of Science)
Assistant in geology

HERBERT P. WHITLOCK C.E. (Columbia) . . Assistant in mineralogy

FREDERICK C. PAULMIER M.S. (Princeton) Ph.D. (Columbia)
Assistant in zoology

JOSEPH MORJE . . . . Clerk and stenographer

C. ADELBERT TRASK . . . . Junior clerk

E. C. KENNY . . . . Stenographer

FIELD ASSISTANTS

In Pre-Cambrian geology
- Prof. H. P. CUSHING, Adelbert College

In Pleistocene geology
- Prof. J. B. WOODWORTH, Harvard University
- Prof. H. L. FAIRCHILD, University of Rochester

In Economic geology
- Dr HEINRICH RIES, Cornell University
- Prof. C. H. SMYTH JR, Hamilton College
- Prof. I. P. BISHOP, Buffalo State Normal School
- Prof. T. C. HOPKINS, Syracuse University
- Prof. W. N. LOGAN, St Lawrence University
- C. J. SARLE, Rochester

Paleontology

JOHN M. CLARKE M.A. LL.D. (Amherst) Ph.D. (Marburg)
State paleontologist

RUDOLF RUEDEMANN Ph.D. (Jena, Germany)
Assistant state paleontologist

D. DANA LUTHER . . . . Field assistant

WILLIAM S. BARKENTIN . . . . Lithographer

G. S. BARKENTIN . . . . Draftsman

JACOB VAN DELOO . . . . Clerk and stenographer

MARTIN SHEEHY . . . . Helper

H. S. MATTIMORE . . . . Preparator

FIELD ASSISTANTS

- Dr A. W. GRABAU, Columbia University
- G. H. CHADWICK, Rochester University
- C. A. HARTNAGEL, Hornellsville
- G. VAN INGEN, Albany

Botany

CHARLES H. PECK M.A. (Union) . . . . State botanist

Entomology

EPHRAIM PORTER FELT B.S. (Boston) D.Sc. (Cornell)
State entomologist

CHARLES M. WALKER B.S. (Mass. Agricultural College) . . Assistant

D. B. YOUNG . . . . Assistant

GEORGE W. V. SPELLACY . . . . Page

Archeology

Rev. WILLIAM M. BEAUCHAMP S.T.D . . . . Author of bulletins

STATE OF NEW YORK

No. 40

IN SENATE

JAN. 6, 1904

57th ANNUAL REPORT

OF THE

NEW YORK STATE MUSEUM

To the Legislature of the State of New York

I have the honor to submit herewith, pursuant to law, as the 57th annual report of the University on the New York State Museum, the reports of the director of the museum and state geologist, of the paleontologist, of the botanist and of the entomologist, with appendixes.

WILLIAM CROSWELL DOANE
Chancellor

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[a] Bulletins are grouped into appendixes according to subject and each appendix is paged separately.

New York State Museum

REPORT OF THE DIRECTOR 1903

To the Regents of the University of the State of New York

I have the honor to submit herewith my reports as director of the State Museum and state geologist for the fiscal year ending Sep. 30, 1903.

Respectfully yours

FREDERICK J. H. MERRILL

Albany N. Y. Dec. 31, 1903

GEOLOGY

The work of this division has continued along the lines of investigation previously in progress. As usual, the autumn, winter and spring have been occupied with the preparation of maps and other matter for publication, and the summer season has been devoted to field work.

Maps

The demand for an up to date geologic map of New York, of moderate size, has led to the preparation for the publication of a new edition on the scale of 15 miles to the inch, which shall extend a short distance beyond the New York State boundary in all directions, so as to show the geologic relations in the immediately adjoining territory. Tracings of the 5 mile base map for reduction to the scale of 15 miles to the inch were prepared under the supervision of Mr C. C. Vermeule, while tracings of the territory adjacent to New York have been prepared in the office by Mr H. H. Hindshaw. The manuscript was placed in the hands of the contractors for engraving, Messrs A. Hoen & Co., in September, and the map will probably be issued within 12 months.

The hypsometric map issued with the 21st Report of the State Geologist has met with a reception indicating much appreciation of its value, and, in accordance with the request of Professor Landreth, is to form a plate in the next report of the State Water Storage Commission, by permission of the University.

Accompanying this report is a map of New York State which shows, by various conventions, the distribution of its mineral resources.

Pre-Cambrian and crystalline rocks

In August the State Geologist took up a comparative study of the rocks of eastern Berkshire county, Mass., as an important help in working out the classification of the crystalline rocks of the Highlands of Putnam county, and the adjacent territory in New York, on which he has been engaged at intervals since 1884. In this he was aided by Mr H. C. Magnus, who had formerly taken part in the work on the Highland area between West Point and Peekskill, and who was occupied during the spring with the

mapping of that portion of Westchester co. included in the Oyster Bay quadrangle.

Two weeks were spent in the Berkshire region and two weeks more in the study of the pre-Cambrian and other crystalline rocks on the shores of Long Island sound between New London on the east and Fairfield on the west.

Then, returning to Pittsfield, some further time was spent in reconnaissance trips from Williamstown on the north to South Norwalk on the south and eastward as far as Springfield. In the course of this work much benefit was derived from conferences with Professors Dale at Pittsfield, Cleland at Williamstown and Gregory at New Haven.

This work has been necessitated by the great mass of geologic investigation carried on in western New England during the past 15 years, on formations in part identical with those of southeastern New York.

In the Adirondack region, Prof. H. P. Cushing had prepared to continue his work of previous seasons, but during the past summer the heavy rainfall rendered field work in the woods impossible except on comparatively few days. It had been intended to finish the mapping of the Long Lake sheet; but, for the above reason, only about half of the work was completed. In the area covered, attention was mainly centered on the hard geology, and the experience of previous seasons was corroborated in that the anorthosite was found, in this district, to grade invariably into a gneissoid gabbro along its border and to become involved with, and apparently cut by, a gneissoid and rather basic phase of the adjoining syenite. Later, a short visit was made to the Little Falls region to clear up one or two points connected with its geology.

In the office the areal mapping of the Little Falls sheet has been transferred by Professor Cushing to the revised map of that quadrangle, which has recently appeared, and the maps transmitted for publication. A short report on the petrography of the Northumberland rock was transmitted by him for publication in the 21st Annual Report of the State Geologist. Much time during

the year was devoted to the preparation of a report on the geology of the northern Adirondack region; and it is well advanced toward completion, so that it will be forwarded for publication early next spring.

Pleistocene

During the field season of 1903 Professor J. B. Woodworth continued his work on the Pleistocene geology of the eastern part of the State. Work was begun in the month of April on the remapping of the Harlem and Brooklyn quadrangles, Mr J. W. Goldthwait being charged particularly with the detailed mapping of the outcrops of bed rock not heretofore shown on geologic maps. This work was advanced by Mr Goldthwait during the summer season to the point of showing in detail the surface geology of the major part of the southern half of the Harlem quadrangle and that of the Brooklyn sheet except the area within the city of Brooklyn. The plan of showing the position of the hundreds of small rock exposures in the former area as an index to the distribution of the thin till, rendered the field work necessarily slow. Mr Goldthwait, on account of illness, was forced to leave the field in the middle of August and has not since returned to it. The glacial striation in the mapped portion of the Harlem area was studied in detail and, through the occurrence of newly made sections, some advance was made in differentiating into definite categories, deposits of drift which heretofore have been represented as undifferentiated glacial materials. Another season's field work will be required to complete the area undertaken.

Several days were devoted by Professor Woodworth during the spring and summer to following the progress of the borings made in the western part of Long Island by the Commission for Additional Water Supply. The sections thus obtained threw much additional light on the structure of the outwash plain, particularly in the area of the Hempstead sheet. A detailed investigation was carried on at the same time in the area by the United States Geological Survey, a preliminary report of the observations of which, including data from many deep wells privately undertaken,

has appeared in various journals. Of the large number of samples of gravels, sands and clays obtained by the Commission referred to, small samples were allotted to the State Museum and are now in Mr Woodworth's charge for such use as can be made of them.

From the 6th of July to the 13th of August Professor Woodworth was granted leave of absence in order to attend to his duties as instructor in one of the summer schools of Harvard University. On the 17th of August he proceeded to Norwood N. Y., where he was joined by Professor Coleman of Toronto Can., and, accompanied by that geologist, conducted a rapid review of the shore lines and evidences of marine submergence lying between Mooers Junction and Adams Center on the southern side of the St Lawrence valley. The primary object of this expedition was to obtain the expert advice of a geologist whose familiarity with the similar phenomena on the Canadian side of the St Lawrence and Ontario valleys was deemed of the highest value in settling mooted points regarding obscure indications of shore lines in this district.

In the course of this examination, Professor Coleman found marine shells (*Macoma groenlandica*) in clays on the outskirts of Ogdensburg. Later, Messrs Coleman and Woodworth found abundant traces of marine shells in stratified sands near the boundary line between the towns of Lisbon and Ogdensburg, including *Macoma calcarea* and one specimen of *Cylichna alba,* a very rare shell within the limits of the State, the only other known locality being that at Port Kent, where it was early noticed by Professor Ebenezer Emmons, and where but two specimens have been collected in the course of this investigation. These Ogdensburg localities are at an elevation of about 275 feet above the sea.

At Norwood, sewer openings which were made in the summer of 1903 revealed many new localities of marine shells, invariably *Macoma groenlandica*. On the hill north of the village, those shells were found in the clays from the sewer trench at an elevation of 360 feet above the sea by the aneroid barometer, or an elevation of 370 feet according to the engineer's levels tied to the

railroad elevation at the station. This locality is the highest yet reported within the limits of the State. The highest known shell locality on the eastern side of the Adirondacks in the Champlain valley is at about 346 feet on the Saranac river at Freydenburg's mills. A locality on the Big Chazy river near Mooers is at about the same level. These marine shells occur through the clayey ground in the village of Norwood (Potsdam Junction of the old maps of the State). This elevation of 360 feet agrees very closely according to Professor Coleman with the upper limit of marine shells on the north side of the St Lawrence valley near Brockville in Canada. Professor Woodworth also reports an occurrence of marine shells in gravel pits along the road between Mooers Junction and Hemingford, Quebec, near the latter place at an elevation of about 270 feet (aneroid). The shells are mostly *Saxicava rugosa* in an excellent state of preservation.

The locality on the Big Chazy near Mooers was found this season and has furnished *Saxicava rugosa, Macoma calcarea, M. groenlandica, Leda arctica, Yoldia* cf. *sapotilla,* and *Balanus* sp.

Marine shells were also observed in a trench in gravels about 1 mile west of Perry's Mills at an elevation of about 300 feet.

Mr William D. Stevenson, customs officer at Mooers Junction, states that he saw shells at a depth of about 8 feet in a well excavated some 15 years ago at McDowell's store near the railroad station at Mooers Junction. There is a marked sand and gravel delta here at an elevation of 280 feet.

A few marine shells (*Macoma groenlandica*) were also seen this last season in a small sand hillock at an elevation of 300 feet on the north side of Tracy brook in the town of Chazy, where that stream is crossed by the state road from West Chazy to Sciota.

The latter part of August and the first part of September were devoted by Professor Woodworth to the completion of the mapping and study of the Mooers quadrangle, the work on which had been far advanced during the preceding season. Search was directed particularly to the finding of marine shells in stream banks and to the tracing of the shore lines which traverse this area. This

map has been prepared to show the distribution of beaches, whether marine or lacustrine. The attempt made last season to discriminate the different classes of drift of glacial origin in the low submerged tract below the 600 foot line was perforce abandoned for most of the area, when it became evident that the glacial deposits had been worked over by the action of waves and currents during the epoch of submergence so as to confuse and commingle materials of diverse origin.

For the purpose of obtaining information concerning the tilted attitude of the beaches and the marine limit in this district, two visits were made to outside points in Canada, the first to the vicinity of Ottawa, and the other to the isolated igneous masses near St John's and Beloeil, in Quebec.

In the case of Monnoir or Mt St John near St Grégoire, no definite upper limit of wave action was observed. The northern and eastern slopes were largely bared of drift. What appear to be fractures partly filled with blocks riven from their walls, are striking features in the upper part of this mount on its eastern aspect. The fractures extend in a northwesterly and southeasterly direction. Professor Woodworth could not determine at the time of his visit that the narrow openings were due to excavation of nonresistant material by waves.

A visit to Beloeil showed heavy pebble beaches developed about the base of this mountain on the west up to an elevation of from 310 to 320 feet above sea level by aneroid compared with the hight of the rail at St Hilaire. An ascent of the northwestern part of the mountain showed no traces of beaches or wave action, but the slopes were everywhere too steep to record clear indications of marine action.

From Ottawa, a reconnaissance was made of the slopes of Kingsmere mountain, northwest of that city, between Chelsea on the Gatineau, and Kingsmere postoffice. Traces of shore lines were found between Old Chelsea and Kingsmere postoffice at 480, 550, 640 and 705 feet by aneroid set at Chelsea Station. A heavy deposit occurs along this road at about 800 feet; but Professor Woodworth was not able to find the criteria which would

satisfy one that it marked a shore line; much less that it was of marine origin. The ascent was continued at the Kingsmere post-office up to 965 feet to the northward, but no definite shore lines were seen.

Professor Woodworth is indebted to the Geological Survey of Canada for advice and literature concerning the study of shore lines about Ottawa, and particularly to Dr R. W. Ells for personally conducting him to the Pleistocene phenomena of the Hull district. He also wishes to express his obligation to Joseph Hobson, chief engineer of the Grand Trunk Railway, at Montreal, for information concerning the altitudes of stations on that road.

During the latter part of the season, Mr P. T. Coolidge, of Watertown Mass., accompanied Professor Woodworth as a voluntary assistant in the search for shore lines and marine shells. Mr Coolidge reports the finding of *Mytilus edulis* in the delta deposits at Port Kent south of the railroad station.

Incidentally, Professor Woodworth reports, as having fallen under his notice in the course of the above journeys, the occurrence of trails of Protichnites on a ripple-marked sandstone layer of the Potsdam at high-water mark under the bank of Lake Champlain at Port Kent near Trembleau Hall.

Professor Woodworth has also prepared a report of progress on the Champlain district, being essentially an account of the general surface geology of the Mooers quadrangle, comprising portions of the towns of Mooers, Altona, Chazy, Beekmantown and Dannemora. A detailed statement of the results of the study of water levels on this area is to be embodied in a report on the marine submergence following the glacial period.

This report forms a Museum bulletin.

Owing to the absence of Prof. H. L. Fairchild in Europe, no investigations were conducted in the work under his charge.

Economic geology

In economic geology, papers on peat and gypsum were completed by Mr A. L. Parsons and an article on abrasives in New York was prepared by Mr H. C. Magnus.

A rearrangement of the collections in economic geology was made in the early part of the year in order better to display them under the improved conditions of lighting in the first floor of the rear wing, to which three new windows have been added.

Mr H. H. Hindshaw, assistant in geology, has been occupied with the compilation of statistics of the mineral products of the State, in editing and reading proof on bulletin no. 62, entitled *Natural History Museums of the United States and Canada,* and in completing for the engraver the hypsometric map of New York.

During the past year the Director has been in correspondence with the New York State Louisiana Purchase Exposition Commission in regard to an exhibit of the mineral resources of New York and has attended one of its meetings. It is probable that an extensive exhibit from the State Museum will be installed at St Louis.

Mineralogy

In the division of mineralogy the principal work of publication consists of a list of the mineral localities of New York State arranged by counties, which has just been completed and will be shortly issued as bulletin 70, mineralogy 3. In this work Mr Whitlock has systematically arranged in tabular form the data collected from various published authorities and embodied such notes and additions furnished by field reconnaissance and study of specimens in available collections as are necessary to make the bulletin a useful work of reference on New York mineralogy, to teachers, students, collectors and curators.

A bibliography, consisting of 231 references to published articles on New York mineralogy, is embodied in the text.

The educational work of the division of mineralogy has been advanced by giving two public lectures, in Graduates Hall of St Agnes School, on subjects connected with mineralogy. The lectures were illustrated by 57 lantern slides and 23 slides showing artificial crystallizations, which were prepared by the division of mineralogy and are available for future work along this line.

The curatorial work of this division has progressed along sev-

eral lines. The plan of placing group and explanatory labels throughout the exhibited material has been developed to a considerable extent. The large collection of duplicate mineral material formerly stored in various places throughout the building has been assembled, sorted and classified, so that duplicate specimens are now readily available.

Additions to the mineral collections have been made by several field excursions, among which may be mentioned in particular a collecting trip to the mines of the Newark Cement Co. at Rondout, which resulted in the acquisition of a large and complete series of calcite and associated minerals from that locality.

PEAT

ITS FORMATION, USES AND OCCURRENCE IN NEW YORK

BY

ARTHUR L. PARSONS

NOTE BY THE STATE GEOLOGIST

In my 21st annual report I published a paper by Dr Heinrich Ries on "The Uses of Peat and Its Occurrence in New York," which represented the available information at that time. In continuation of the work done by Dr Ries, Mr Arthur L. Parsons has prepared the following paper, which, while duplicating a part of what Dr Ries has published, forms a *résumé* of our present knowledge on the subject of this material, which probably in the near future will become of economic importance through the development of processes for cheaply making it into available fuel.

F. J. H. MERRILL

CONTENTS

PEAT

ITS FORMATION, USES AND OCCURRENCE IN NEW YORK

PART I

INTRODUCTION

The purpose of this paper is to give reliable information concerning the occurrence, formation and uses of peat, and descriptions of the principal deposits of this material in this State. Geologic considerations have not been taken up in detail, because it is chiefly the aim of the author to discuss the economic importance of the material in agriculture and the arts. Many attempts have been made by different people at various times to prepare and market peat in New York State, but heretofore the undertakings have soon been given up. During the summer of 1902, when it was almost impossible to secure anthracite coal in New York city, peat was brought to the city from some of the swamps on Long Island; but, in spite of the demand for fuel, there was little or no sale for this material. A careful inspection of the more important deposits in the State and a study of the fuel value of peat of average composition and the products which may be obtained from it have forced on the author the conclusion that peat deposits may be utilized to advantage as sources of fuel when the material is properly prepared. In most European countries peat is used quite extensively, and new processes of manipulating the raw material give a product that is finding favor in all kinds of manufacturing establishments.

Peat is thus defined by the *Standard Dictionary:* "A substance consisting of partially carbonized vegetable material, the result of the decomposition of various plants (sometimes aquatic) in the presence of water; found usually in marshes, bogs, etc. At the surface it contains considerable water, but deeper it is more compressed and gradually approaches the condition of lignite."

It is in fact the first stage in the process of coal formation. The definition given above gives only a vague idea of the character of the substance, and, in order to understand its nature, it is necessary to make a study of the conditions governing its formation, and to this end a classification and description of swamps and marshes must be given.

The value of the swamps in New York State is ordinarily greatly underestimated both from lack of information in regard to their extent and ignorance of the manner in which they may be reclaimed for agricultural purposes. Ordinarily unimproved swamp land is assessed at about $5 per acre, but, when this same land is drained, it sells ordinarily at from $200 to $500 per acre, so that, when it is known that the estimated area of the swamps of New York is more than $\frac{1}{20}$ of the State,[1] the enormous value of these tracts is at once apparent.

It is impossible to give a complete list of the swamps of the State, because in many cases the deposits may cover only a few acres or even less than an acre, but a study of the topographic maps of the United States Geological Survey will give the location of the more important ones, though it must ever be borne in mind that all swamps are not peat deposits, though all peat deposits are or have been swamps. Many of these swamps are spoken of as muck swamps even when the best of peat is found in them, and the term peat is not common in referring to swamp deposits in this country. The reason for this is undoubtedly the fact that peat is used in this country almost entirely as a fertilizer. The original meaning of the word muck is moist manure. From its resemblance to stable manure, peat came to have the same name, more particularly because the two were commonly mixed to make a compost. The name thus came to be applied to peat when used as a manure. Again, peat containing a large percentage of ash is known as muck, possibly from the fact that this kind of peat would be used as a manure, while the better peat was saved for fuel.

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[1] Shaler estimates the area of inundated lands in New York State to be between 2000 and 3000 square miles. U. S. Geol. Sur. 10th An. Rep't, p.311.

In general, a swamp or marsh is formed when the drainage in any locality is so arrested that sufficient water is retained to prevent complete decay of the vegetable matter that may be deposited. The greater amount of vegetable matter that accumulates in a swamp is not due to the increased luxuriance of the vegetation; in fact, the amount of vegetable matter that may be deposited on the uplands may be greater than that which accumulates in a swamp. On the upland, where the drainage is unimpeded, any accumulation of vegetable matter is exposed to frequent alternations of moisture and drouth, which hasten the process of decay; but in a swamp, where the moisture is always about the same, the decomposition is very slow, and is rather a process of deoxidation than oxidation, or decay. The various processes of decomposition are well shown in a fence post when set in moderately moist soil. The portion above ground is to all intents and purposes in a dry atmosphere, and the rate of decay is very slow. For a few inches above and below the surface of the ground the decay is very rapid, because the soil retains the moisture after rains; but in time of drouth this part becomes dry. This alternation of moisture and drouth furnishes an ideal condition for decay, and, when a post breaks, it is invariably at this point. Below this zone of decay the moisture is more constant, and the decay is less, and in many cases, when an old post is dug up, it is found to be sound at both ends and almost rotted off at the surface of the ground. This will serve as an explanation of the fact that all that may be left of a great deposit of vegetable matter where drainage is unimpeded is a thin deposit of mold, while the same amount of vegetable matter in a swamp forms a thick bed of peat, which in some cases may be fifty or even a hundred feet thick.

Inundated lands

The most complete classification of inundated lands that has come to the notice of the author is the one by Shaler [10th An. Rep't U. S. Geol. Sur. p. 264] which is given below.

Classification of swamps

Marine marshes	Above mean tide	Grass marshes Mangrove marshes
	Below mean tide	Mud banks Eel grass areas
Fresh-water swamps	River swamps	Terrace Estuarine
	Lake swamps	Lake margins Quaking bogs
	Upland swamps	Wet woods Climbing bogs
	Ablation swamps	

Description of swamps

The distinction made by Shaler between the terms marsh and swamp, confining the former to marine formations and the latter to fresh-water deposits, is one which might be carried still farther to distinguish between bog, mire, morass etc. It seems to be the general impression that all these wet lands are areas of soft, black mud and slime overgrown to a certain extent with marsh grasses and cat-tails, which form a mire that is absolutely impassable, whereas most fresh-water swamps have a floor of moss or interlaced roots and fallen trees which make a perfectly safe foothold for the person who may attempt to cross.

In New York State examples of all the above mentioned classes of swamps are to be found with the exception of the mangrove marshes. As a rule, only the fresh-water swamps of the State are of any importance as sources of peat, though the value of the salt marshes, if reclaimed, would be very great as farm or garden lands.

Marine marshes. The four classes of marine marshes, though entirely distinct, are not as widely separated as appears at first; they are in fact separate steps in the same process. For a strictly logical classification the arrangement would be, (1) eel

grass areas, (2) mud banks, (3a) grass marshes and (3b) mangrove marshes.

These marine marshes are in most cases formed in bays where the wave action is slight. Their history in general is as follows: The waves wear away large quantities of material from rocky headlands and beds of glacial drift. The rock fragments are carried to adjoining beaches, where the pebbles are slowly ground to a fine mud, which may be carried by even a slight current to a great distance. Clay from the drift is reduced to the same condition. The mud is not deposited to any great extent where the waters are disturbed; but, when it is driven into protected bays, it slowly settles and forms a bed on which a crop of eel grass rapidly springs up. These eel grass fields are usually covered with 3 or 4 feet of water at half tide, when the tidal current is greatest. On account of the habit of the plant, the tidal current is practically stopped where the grass is growing, though the water above the grass is usually more or less laden with fine mud, which slowly settles to the quiet water below and, becoming entangled by the stems of the grass, gradually increases the thickness of the deposit in this place. The dying portions of the eel grass and the bodies of many Crustacea and Mollusca are deposited with this mud and rapidly increase the thickness of the deposit. When the deposit reaches such a thickness that it is dry at low tide, the eel grass ceases to grow, and the increase in the deposit comes entirely from the sediment borne in by the tide. On the highest part of the mud flat thus formed, grasses and other forms of vegetation begin to grow and gradually form a covering which raises the level of the marsh so that it is only overflowed by the highest tides. Sometimes the mud flat between the eel grass area and the grass marsh is as much as a mile wide, but this is exceptional. The growth of the deposit is more rapid in the grass marsh than in the eel grass area, because the plant, leaves and stems are larger, and for this reason gather sediment more effectively. The grassy marshes are more carbonaceous than the eel grass areas, but they rarely contain 50% of carbon and usually do not furnish a supply of peat suitable for fuel.

When reclaimed by drainage, they make excellent garden land, though the cost of drainage is greater than in the case of most fresh-water swamps.

Mangrove marshes. South of Fernandina and thence throughout Florida, mangrove marshes take the place of grass marshes. The roots of the mangrove develop in salt water, and the plant spreads by means of rootlike processes which implant themselves in the marine mud, while the tree itself is entirely above water.

Fresh-water swamps. Though marine marshes and fresh-water swamps are sharply defined in the character of the vegetation and in the periodicity of inundation, the two have their point of meeting in the estuarine or delta swamps. It is hard to draw the line of distinction between the different classes of fresh-water swamps and a study of conditions will force on the student the conclusion that all fresh-water swamps are modifications of lake swamps. The causes of lake formation in general will not be discussed for the reason that this article has only to do with lake filling. A logical treatment of the subject might start with a discussion of any one of the four classes of fresh-water swamps, but for convenience the author will discuss them in the order given below:

1 Lake swamps
- 1a Lake margins
- 1b Quaking bogs

2 River swamps
- 2a Terrace
- 2b Estuarine or delta

3 Upland swamps
- 3a Climbing bogs
- 3b Wet woods

4 Ablation swamps

Lake swamps. Near the shores of almost any lake or pond a growth of rushes and other aquatic plants may be seen, and usually they are found more abundant in sheltered bays where the

waves have very little effect. This growth of plants retards the motion of the water, so that any sediment which may be in the water is deposited, and at the same time the shore is not subjected to the beating of waves. Under these conditions a fringe of moss springs up and rapidly spreads out over the surface of the water. Just a little in advance of the mosses a floating mat of cat-tails is usually found, which is an important help in the spread of the moss by furnishing greater protection from the waves than is given by the rushes alone. Though these mosses grow most luxuriantly in such locations, the growing part must be slightly above the water level, and the cat-tails furnish a support on which the mosses grow more rapidly than when alone, because more of the growing part is above the water.

As soon as the moss has formed a mat over the surface, certain grasses and ferns spring up and add to the deposit of organic material formed by the dead plants. As the mat becomes deeper, heath plants begin to grow and by their more woody stems help to make a more porous deposit, on which larger bushes take root. As soon as the mat becomes deep enough to reach the bottom of the lake near the shore, the deposit gradually rises above the level of the waters of the lake, and small trees find suitable conditions for their growth. The effect produced by the trees and bushes is to form clumps of vegetation above the general level of the moss, so that many trees which ordinarily are not supposed to endure such moist conditions grow in luxuriance.

Such a bog in time will entirely cover the lake, and the zone of rushes and water lilies will be the first to be eliminated, then the cat-tails disappear, and the moss and other plants will occupy the entire surface. In the center of the lake a quaking bog will be left; but, by the gradual filling both by pressure from the growth of the lateral deposits and by the deposition of decomposed particles from the overlying vegetation, the bog becomes a solid mass of peat. As soon as this occurs, the level of the entire bog begins to rise, and the spread of bushes and trees over the entire surface is very rapid.

In some cases the floating bog becomes heavier than the water and " either breaks and sinks suddenly to the bottom or is slowly and gradually lowered into it and covered with water."[1] Authentic instances of such sinking are rare; but about the year 1500 a forest in the Valdes-Ponts sank in one night, giving place to the Lac d'Etaillères. In this way most, if not all, of the submerged forests have probably been formed and brought to their present position, and it is the most logical explanation that can be given for the alternation of peat and marl in many swamps.

River swamps. Terrace swamps are in certain respects merely modifications of lake swamps and are formed in depressions in river valleys. These depressions are caused in a great measure by the deposition of sediment near the river bank in time of high water, thus forming a dike which prevents any water which may overflow from the river from again returning to the watercourse when the flood recedes. The pools formed in this way become more or less covered with swamp vegetation and in time are filled with a deposit of impure peat and muck. The oxbows or moats of a river system, when cut off from the river, form pools which fill up in the same manner as a lake, though floods leave deposits of mud on the surface of the vegetation, thus forming a more mixed deposit than is formed in a true lake, where little sediment can reach the still water beneath the floating vegetation, and none at all can go above it.

Delta or estuarine swamps. The dikes or levees formed by a river naturally extend to its mouth and are gradually extended beyond the shore line. In many cases the river breaks through this wall and may have several outlets, thus forming a delta. The space between these outlets is usually lower than the banks of the river, and swamp vegetation springs up and a delta swamp is the result. In case this delta is at the head of a lake, the gradation from the delta formation to the lake margin swamp may be so gradual as to make it difficult to tell where the line of division should come. True delta swamps are not common in

[1] Lesquereaux, L. Pa. Geol. Sur. An. Rep't. 1885. p.107–8.

New York, though the "vleys," or swampy borders of the Hudson come under that head.

Upland swamps. Upland swamps are found in regions which are approximately level. In a region where the surface does not have a fall of more than 4 or 5 feet to the mile, any vegetation which may spring up has a tendency to retard the flow of the rainwater. When leaves or the trunks of trees fall, they act as a sponge and retain the water, thus furnishing better conditions for the growth of mosses and grasses. If the plain is originally a woodland, the forest may be destroyed by the swampy conditions thus produced, or it may be replaced by a growth of the trees that are ordinarily found in swamps. It may seem farfetched to call such a swamp a modification of a lake swamp; but, when one considers that every fallen twig and every root is a dam which holds back the water, it is apparent that the whole area is made up of little lakes which furnish the proper conditions for the growth of the swamp vegetation. In such a swamp the rush and cat-tails stage may be entirely lacking, and the sphagnum and grasses will be the most important factors in the swamp formation.

Climbing bogs. Climbing bogs are the natural spread of any swamp to higher levels on account of the great amount of moisture that is absorbed by the sphagnum and other mosses of the swamp, but they are of no importance in this State.

Ablation swamps. Ablation swamps, otherwise known as corrosion spring swamps, are not common, but are caused by the gradual subsidence of the surface of the ground on account of the solvent action of water on either the surface rock or some of the underlying strata, forming a pool or depression in which swamp vegetation springs up. The solution of salt and gypsum in central and western New York is without doubt an important factor in the formation of swamps in that part of the State, though in most cases other causes have an important share.

Upland swamps and ablation swamps do not depend to such a degree on the presence of terrestrial water for their growth as

the lake and river swamps, but get a large part of the moisture necessary for their formation from a humid atmosphere. In some cases springs may furnish the supply of water; and in the case of some swamps in glacial kettles the only apparent supply is rain water.

PART 2

Classification of peat based on vegetation

Somewhat dependent on the differences in inundated lands is the classification of peat based on the variety of plants which go to make up the mass. Though no large mass of peat is made up of any one kind of vegetation; yet a general distinction can be drawn which is based on the most important class of plants present. The following classification is given by Wagner:[1] (1) "bog peat consisting principally of species of sphagnum; (2) heath peat, formed chiefly from the roots and stems of Erica and Calluna; (3) meadow peat, formed principally from grass and sedges; (4) forest or wood peat, formed from the wood of trees; (5) sea peat, formed from sea weeds."

Some difficulty is encountered in referring some of the New York deposits to any one of these classes, because of the many important varieties of vegetation present in the same swamp. There is no difficulty in referring the Montezuma marshes to the third class, inasmuch as they are principally composed of cat-tails and grasses; but in the case of the Cicero and Oak Orchard swamps and the Drowned Lands of the Wallkill, it is decidedly a question; borings bring up pieces of wood from all depths, and the surface is covered with a luxuriant growth of trees, but at the same time sphagnum and other mosses form a dense carpet, which rapidly covers any fallen trees and may furnish a greater amount of material than the trees. Shrubs and heath plants are also found, so that these swamps seem to be filled with a more composite deposit than is indicated by any of the classes given by Wagner.

Classification of peat based on physical condition

Another classification that has been used is based on the difference in texture of the upper and lower layers of the deposit.

[1] Wagner, Rudolph. Manual of Chemical Technology.

Cleaveland in his mineralogy[1] distinguishes between (1) fibrous peat, or turf, and (2) compact peat, or peat proper. His definition and description of peat are so good that I quote them in full.

Peat consists essentially of vegetable matter in various states of decomposition; but is more or less mixed with earths and salts. It appears to differ from vegetable earth [or mold] by retaining nearly all the principles of the vegetable, though these principles may have formed combinations which did not exist in the living plant.

We notice two varieties of peat, depending chiefly on the degree of decomposition in the vegetable. (1) Fibrous peat. This variety, sometimes called turf, is composed chiefly of vegetable fibers, variously interlaced, and united by a slimy, vegetable matter in a more advanced state of decomposition. Its texture is of course very loose. Hence we perceive the roots, stems and leaves of various plants, which grow in swamps, bogs, marshes or heaths; indeed, it sometimes seems to be composed almost entirely of leaves. When dry, it is lighter and more elastic than compact peat, and its color is usually less dark. (2) Compact peat. When recently dug, it forms a very slimy mass, soft to the touch, and sufficiently tenacious to be cut or molded into small regular solids, like a brick. When dry, its texture becomes more or less firm and compact, and it exhibits an earthy fracture. It is harder, heavier and blacker than the first variety. It embraces few or no visible remains of the organic parts of vegetables and seems to have originated chiefly from aquatic plants. In some rare instances its fracture is glossy like resin.

The two preceding varieties pass insensibly into each other and frequently occur in the same bed. In this case, the upper part of the bed is loose and fibrous, having undergone only partial decomposition; but, on approaching the lower parts, the remains of the vegetable fiber gradually disappear, and the peat becomes more compact, in consequence of the more complete decomposition of the vegetable and of the pressure of the superincumbent mass.

Process of peat formation

The manner in which a peat bog is formed has been described under the head of lake swamps, but the process of peat formation is a subject for theories. It is known that the vegetable matter loses certain percentages of carbon, hydrogen and oxygen, but just what

[1] Cleaveland, P. Elementary Treatise of Mineralogy and Geology. 1822.

the chemical changes are which take place is unknown. The process of peat formation is the first stage in the formation of coal, and the following table[1] shows the manner in which peat and the principal varieties of coal may be formed from woody tissue by the loss of constituents.

		C	H	O	total	
	Wood	49.1	6.3	44.6	100	
I	Loss	21.5	3.5	29.1	54.1	Loss equivalent to 40% CO_2 and 14.2% CH_4
	Peat	27.6	2.8	15.5	45.9	
	Percentage	60.1	6.1	33.8	100	
II	Loss	8.1	2.2	21.5	31.8	Loss equivalent to 29.6% CO_2 and 2.2% H, uniting with outside O
	Peat	41	4.1	23.1	68.2	
	Percentage	60.1	6	33.9	100	
III	Loss	2	1.6	18.15	21.75	Loss equivalent to 7.33% CO_2 and 14.42% H_2O
	Peat	47.1	4.7	26.45	78.25	
	Percentage	60.2	6	33.8	100	
IV	Loss	18.65	3.25	25.4	= 47.3	Loss equivalent to 34.9% CO_2 and 14% CH_4
	Lignite	30.45	3.05	19.2	= 52.7	
	Percentage	57.8	5.8	36.4	100	
V	Loss	6.4	1.95	17.2	25.55	Loss equivalent to 23.6% CO_2 and 1.95% CH_4
	Lignite	42.7	4.35	27.4	74.45	
	Percentage	57.3	5.8	36.9		
VI	Loss	1	1.4	13.75	16.15	Loss equivalent to 3.6% CO_2 and 12.5% H_2O
	Lignite	48.1	4.9	30.85	83.85	
	Percentage	57.3	5.9	36.8		
VII	Loss	31	5.1	41.9	78	Loss equivalent to 57.6% CO_2 and 20.4% CH_4
	Bituminous coal	18.1	1.2	82.2	22	
	Percentage	82.2	5.5	12.3		
VIII	Loss	14.8	4.01	39.45	58.3	Loss equivalent to 54.24% CO_2 and 4.01% H oxidized
	Bituminous coal	34.3	2.29	5.15	41.7	
	Percentage	82.2	5.5	12.3		
IX	Loss	4.3	3.3	37.9	45.5	Loss equivalent to 15.7% CO_2 and 29.8% H_2O
	Bituminous coal	44.8	3	6.7	54.5	
	Percentage	82.2	5.5	12.3		
X	Loss	34.57	6.03	43.95	84.55	Loss equivalent to 60.79% CO_2 and 24.12% CH_4
	Anthracite	14.53	.27	.65	15.45	
	Percentage	94.04	1.75	4.21		
XI	Loss	16.17	5.7	43.12	64.99	Loss equivalent to 59.29% CO_2 and 5.7% H oxidized
	Anthracite	32.93	.6	1.71	35.01	
	Percentage	94.06	1.71	4.23		

It is seen from the table that the conversion of woody tissue to peat, lignite and bituminous coal may be brought about in three distinct ways and the change to anthracite may take place in two ways with little or no chemical action between the woody fiber and outside material. The probable stages in the change are indicated in numbers I, IV, VII and X.

By reference to this table it will be seen that peat and lignite are almost identical, and that the peat is somewhat more

[1] Bischof, Gustav. Elements of Chemical and Physical Geology. 1:276–80. Tr. by B. H. Paul & J. Drummond.

decomposed than the lignite. This, however, is not necessarily so, for the upper layers of a bed of brown coal may show peat, which in all probability would not have reached the same degree of decomposition as the coal beneath. This gradation from peat to brown coal or lignite is shown in a deposit of brown coal at Grovetown Ga.

From this table it will be seen that the change from wood and moss to lignite and peat consists in the evolution of certain percentages of carbon, oxygen and hydrogen, which leaves a relatively increased percentage of carbon and a decreased percentage of hydrogen and oxygen. The principal products given off in this change are marsh gas, carbon dioxid and water. Some nitrogen is given off; but this may ordinarily be neglected on account of the small amount present, and in cases where large quantities may be found, it is probably due to the decomposition of animal matter or to the ammonia that is brought down by rains. Analyses of the gas given off from peat beds do not give data that can be depended on in determining the formation of peat. The evidence of this is shown by a comparison of the analyses of sphagnum, compact peat and the gas from a peat bed as analyzed by Websky.[1]

Composition exclusive of ash

	Carbon	Hydrogen	Oxygen	Nitrogen
1 Sphagnum	49.88	6.54	42.42	1.16
2 Peat	50.33	5.99	42.63	1.05
3 Peat	50.86	5.8	42.57	.77

1 Sphagnum moss from a bog at Grunewald near Berlin.

2 Peat from same place.

3 Peat from the high moors (Hochmoor) of the Upper Harz, 2500 feet above the North sea.

The analyses of the gas from a peat bed by the same authority gives CO_2 2.97; CH_4 43.36 and N 53.67.

Now, granting that only half the original material in the sphagnum had been evolved as gas, it will readily be seen that such

[1] The foregoing is quoted from Percy's *Metallurgy*, where the following reference is given: Websky, Justus. Erdmann's Journal für Praktische Chemie. 1864. 92:98.

a percentage of nitrogen as the result of the decomposition of vegetable matter is an impossibility, for the peat contains nearly all the original nitrogen of the plants, or its place has been taken by nitrogen washed in by rains. Again, though the decomposition is largely a process of deoxidation, and a much smaller percentage of CO_2 is given off than is the case when the vegetation decays under ordinary conditions, yet the small percentage of this gas given is probably incorrect, for water takes up its own bulk of carbon dioxid, while only about 5% of its bulk of marsh gas is taken up by water. It will thus be seen that the tendency is for the CO_2 to be dissolved in the water and taken from the water by Mollusca, while the marsh gas is thrown off into the air. In this way the small percentage of CO_2 in the gas from a bog may possibly be explained. In addition, we must account for the disappearance of a large percentage of oxygen, which can not be accounted for in any other way than by supposing that the amount of CO_2 formed is greater than is indicated by the analyses given above.

Analyses of peat

The composition of peats from various places is shown in the following table of analyses:

Chemical composition of peat

SOURCE	Org.	H_2O	Fe_2O_3 and Al_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	SO_3	CO_2	SiO_2	Cl	Ins.	Authority
Michigan:														
Meare near Bridgewater.....	97.78	.....	.536	$CaCO_3$ .855	.144	.131	.065	.053	.051	....	.403	....	.....	Mich. Agric. Rep't 1865. p.208
New Jersey:														
1 Black brook meadows, Columbia turnpike, Morris co.	65.61	16.16	3.19	3.86	.37	.31	.....	.93	.89	.09	8.64	....	.....	Geol. of N. Jersey. 1868. p.481
2 Peat cut for fuel at Columbia, Morris co., 2 to 3 feet below surface...........	66.87	15.15	3.97	3.17	.39	.27	.....	.1	2.46	....	7.63	....	.....	Geol. of N. Jersey. 1868. p.481
3 Allandale bog in Bergen co.	83.8	11.7	.42	1.46	.17	.08	.....	.05	.74	.04	1.07	....	.....	Geol. of N. Jersey. 1868. p.481
4 Beavertown, Morris co.....	69.8	16.8	2.92	3.34	.27	.02	.....	.19	.76	.43	5.36	....	.....	Geol. of N. Jersey. 1868. p.481

Rhode Island peats[1]

		H_2O	Ash	Vegetable matter	SiO_2	Fe_2O_3 Al_2O_3	CaO	MgO	K_2O_2 loss	
1 Cranston		.....	13	87	8	2.2	2.8	.....	tr.	
2 Block Island		25.25	6.35	63.4	4.5	.75	1.1	.....	.....	
3 Bristol	light and porous	.....	13.9	86.1	.....	.....	.....	.....	.....	
4 Cumberland		.....	76	24	69.3	3.2	.5	.3	.....	
5 Cumberland Hill	light, flaky and fibrous, color brown	.....	2.15	97.85	.45	.25	1.3	.....	1.5	
6 N. Kingston	compact, red brown	.....	25.6	74.4	21.2	2.4	1.5	.....	.5	
7 N. Kingston	heavy	.....	65	35	57.6	.5	5.5	.....	.....	
8 S. Kingston	ashes mostly silica	.....	62.5	37.5	.....	.....	.....	.....	.....	
9 S. Kingston	gravelly, rather heavy and fine	.....	48.4	51.6	41.35	4.2	1.2	.3	.....	
10 S. Kingston		.....	10.5	88.5	7	1.5	.6	.....	.....	1.2 phosphate of lime
11 Cranston		.....	7.9	92.1	6.3	.9	.7	.....	.....	
12 Pawtucket		.....	11.4	88.6	9.5	1.9	.....	.....	.....	
13 Wickford		15.9	11.5	72.6	8.9	1.5	1.1	.2	.....	
14 Woonsocket		10	1.8	88.2	.5	.3	.6	.....	.....	
15 Warwick		13.5	49	37.5	40.7	5.1	3.2	.....	.....	
16 Warwick		.....	4	96						
17 Wickford		.....	12	88	.....	.....	.....	.....	.....	
18 S. Kingston		.....	17.5	82.5	12	2.1	2.5	.5	.4	
19 Pawtucket		.....	32.5	67.5	.....	.....	.....	.....	.....	
20 Warwick, Pottwoomet		.....	10.5	89.5	.....	.....	.....	.....	.....	
MASSACHUSETTS										
21 Lexington		26	69	69	.1	.6	.....	.....	tr.	3 phosphate of lime

[1] Jackson, Charles T. Report on the Geological and Agricultural Survey of the State of Rhode Island. 1840.

Additional analyses

SOURCE	H_2O	Ash	Organic matter	Authority
1 Bedford N. H.	......	7	93	Analyses 1–8 are taken from *Geology and Mineralogy of the State of New Hampshire*, 1844, by Charles T. Jackson.
2 Bedford N. H.	5.8	4.6	89.6	
3 Canterbury N. H. ...	......	6.2	93.8	
4 Canterbury N. H. ...	13.7	23.4	62.9	
5 Lyndeborough N. H.	21	12.3	66.7	
6 Franconia N. H.	......	26.3	73.7	
7 Merideth N. H.	......	5.1	94.9	
8 Bedford N. H.	......	24.3	76	
9 St Dominique Can. .	......	7.27	92.73	Geology of Canada, 1863.
10 St Dominique Can. .	......	6.75	93.25	
11 Rochester N. Y. ...	14.47	2.15	83.38	Fairchild, H. L. & Barnum, E. G. Pinnacle Peat Marsh, Proc. Roch. Acad. of Sci., v.3. Edward Hirschfield, analyst.
12 Rochester N. Y.	14.23	3.05	82.72	
13 Rochester N. Y.	14.51	5.08	80.41	
14 South Salem N. Y. .	19.43	21.27	59.3	R. A. Fisher, analyst.
15 Ardennes, France...	30.5	8.3	61.2	M. Diday, analyst, quoted from Taylor's *Statistics of Coal*.

Connecticut peats[1]

SOURCE	Analyst	Org.	Ash	Water	Place
1 Goshen Ct	E. H. Twining	52.42	35.21	12.37	Fresh-water swamp
2 Goshen Ct	"	71.67	8	20.33	"
3 Goshen Ct	"	80.35	4.52	15.13	"
4 Milford Ct	"	77.1	3.23	19.67	"
5 Milford Ct	"	84.4	2	13.6	"
6 Plainville Ct	"	52.1	29.2	18.7	"
7 Griswold Ct	"	52.45	34.7	12.85	"
8 Berlin Ct	"	69	13.59	17.41	"
9 Colebrook Ct	"	57.05	4.57	33.88	"
10 West Cornwall Ct.	"	65.4	14.89	19.71	"
11 North Granby Ct.	"	41.16	47.24	11.6	"
12 Poquonnock Ct ...	"	76.03	5.92	18.05	"
13 Poquonnock Ct ...	"	74.17	8.63	17.2	"
14 Brooklyn Ct	"	76.45	7.67	15.88	"
15 Brooklyn Ct	"	77.52	9.03	13.45	"
16 Brooklyn Ct	"	23.88	67.77	8.35	"
17 Brooklyn Ct	"	60.1	25.78	14.12	"
18 Collinsville Ct	R. A. Fisher. .	31.03	57.78	11.19	"
19 Collinsville Ct	" ..	15.41	50.01	34.58	"
20 Collinsville Ct	" ..	13.68	29.21	57.11	"
21 New Haven Ct	" ..	52.02	36.52	11.46	Salt marsh
22 New Canaan Ct ...	" ..	23.81	68.9	7.29	Fresh-water swamp
23 New Canaan Ct ...	" ..	23.88	70.16	5.96	"
24 New Canaan Ct ...	" ..	26.44	66.9	6.66	"

[1] Johnson, S. W. Essays on Peat, Muck and Commercial Manures.

Connecticut peats (*concluded*)

SOURCE	Analyst	Org.	Ash	Water	Place
25 Rockville Ct.....	R. A. Fuller..	64.23	5.41	30.36	Fresh-water swamp
26 Rockville Ct......	" ..	83.88	2.21	13.91	"
27 Rockville Ct......	" ..	52.16	9.63	38.21	"
28 Brooklyn Ct......	" ..	55.05	6.37	38.58	"
29 New Haven Ct....	" ..	57.57	27.13	15.3	"
30 Stonington Ct....	" ..	64.81	8.68	26.51	Originally fresh, now covered with salt water
31 South Salem N. Y.	" ..	59.3	21.27	19.43	Fresh-water swamp
32 Salisbury Ct......	" ..	55.23	16.7	28.07	"
33 Stonington Ct....	" ..	28.37	61.85	8.78	Salt-water swamp

Ontario peats[1]

BOG	Water in original sample	Calculated on 15 % water content		
		Volatile combustibles	Fixed carbon	ash
	Per cent	Per cent	Per cent	Per cent
1 Welland				
From top to 20 in. depth..................	82 2	59.27	21.66	4.07
From 20 in. to clay bottom at 42 in......	87.48	56.78	21.05	7.17
2 Beaverton				
From top to 7 in. depth..................	62.98	57.13	11.67	16.2
From 7 in. to 15 in. depth............. ...	83.31	67.58	10.39	7.03
From 15 in. to 26 in. depth...............	84.86	73.6	4.72	6.68
From 26 in. to 40 in. bottom.............	82.98	56.93	.40	27.67
3 Perth				
Top 5 ft..................................	....	54.72	19.85	10.43
Top 4 ft.	....	57.81	18.92	8.27
4 Brunner				
Top 3 ft.	....	60.1	15.7	9.2
5 Brockville				
Upper stratum, 3 ft.	....	55.08	20.62	9.3
Part lower stratum, from 3 down to 5 ft.	....	57.15	13.73	14.12
6 Rondeau				
Lower stratum beneath surface growth..	....	58.56	23.29	3.15
" ..	....	54.6	22.44	7.96
From stock pile	....	67.99	11.06	5.95
7 Newington				
Sample no. 1...............	87.94	56.74	27.21	1.05
2..........................	86.66	54.42	28.61	1.97
3..........................	87.62	58.70	24.73	1.57
4..........................	90.12	58.15	25.3	1.55

[1] Carter, W. E. H. Peat Fuel: its Manufacture and Use. p.18.

Analyses of Irish peat[1]

SOURCE	Carbon	Hydrogen	Oxygen	Nitrogen
Philipstown, surface peat	53.694	6.971	32.883	1.4514
Philipstown, dense peat	60.476	6.097	32.546	.8806
Bog of Allen, surface peat	59.92	6.614	32.207	1.2588
Bog of Allen, dense peat	61.022	5.771	32.4	.807
Twichnevin, surface peat	60.102	6.723	31.288	1.8866
Shannon, surface peat	60.018	5.875	33.152	.9545
Shannon, dense peat	61.247	5.616	31.446	1.6904

[1] Dublin Journal of Industrial Progress. Ash and moisture not given.

Methods of determining fuel value

Though these analyses do not show the exact value of the materials for fuel or for fertilizer, they may be used as a standard of comparison and indirectly assist in determining the fuel value; but for accurate results the only method of determining the fuel value is by using a calorimeter. In determining the value of peat as a fertilizer, it is doubtful whether any of these analyses are of any value, as the benefit derived from peat depends not so much on the chemical composition as on the mechanical effect on the soil and its property of absorbing ammonia. In determining the value of fuels, it is necessary to have a unit of measurement; and in England, the United States and among most English-speaking people this standard is the British thermal unit, while in France and Germany the standard unit is the calory.

Inasmuch as fuels are composed for the most part of carbon and hydrogen, it has been agreed in the scientific and commercial world that all the carbon must be burned to carbon dioxid and all the hydrogen must be burned to water in determining the value of any fuel. The sulfur and nitrogen are ordinarily neglected in these determinations. The amount of heat absorbed by a unit of pure water when its temperature is raised 1° F. is known as the British thermal unit. Ordinarily the unit of water is the pound; and, as heat and dynamic energy may be considered convertible, the value of the fuel in foot pounds may be obtained by multiplying the number of British thermal units by 772. The calory is the

quantity of heat absorbed by a unit of pure water when its temperature is raised 1° C. Both the gram and the kilogram are used as the unit weights of water.

An approximation of the result obtained by direct determination in a calorimeter may be obtained from the ultimate analysis of the fuel by the following formula, which gives the value as compared with pure carbon.

$$V = C + 4.25\left(H - \tfrac{1}{8}O\right)$$

where

C=percentage of carbon
H= " hydrogen
O= " oxygen

In this case the amount of carbon, hydrogen and oxygen in the fuel must be known, though the sulfur and nitrogen may be neglected on account of the small amount present in most cases. It will be seen that the only analyses in the tables given above that can be used in calorimetric determinations by this method are those of Irish peat quoted from the *Dublin Journal of Industrial Progress*. Some authors hold that the heat value of a fuel may be determined more accurately by using a proximate analysis; but this is doubtful, though in the case of peat a close approximation might be obtained in dry fuel. If the volatile matter were all marsh gas, the proximate analysis would do as well as the ultimate analysis; but the presence of other volatile matter complicates the computation. Another method of determining the heating power of a fuel is by mixing a given weight of the fuel with a quantity of litharge and heating the mixture in a crucible; the heating power is in proportion to the quantity of lead reduced. Experiments made by Mr C. Cowper gave the following results.[1]

10	grs. of	Newcastle coal	284 grs. lead
10	"	oven coke	302 "
10	"	common peat, Bog of Allen	144 "
10	"	same coked in crucible	259 "

[1] Taylor, R. C. Statistics of Coal. Phila. 1848. p. 385.

From this it would appear that 2 tons of peat are equal in fuel value to 1 ton of Newcastle coal.

PART 3

Economic value of swamps

In addition to peat, many valuable materials are found in greater or less abundance in different swamps; and some of the more valuable of these and their uses are mentioned with the discussion of the uses of peat.

Timber. The first product that is of utility in many of the swamps is the large supply of timber. Many of these tracts are covered with a dense growth of white cedar, while others furnish large quantities of maple, birch, elm and ash. The growth of trees is so rapid that with a little care a continuous supply of good timber might be secured. For such a use of the swamps, only the wood that has reached its maturity should be cut, thus allowing the half grown trees to become of value. The usual practice of cutting every tree, whether large or small, greatly depreciates the value of any swamp as a timber producer.

Marsh grass and cat-tails. Large crops of marsh hay are taken from some of the salt marshes, and this material finds a good market as a packing material. In some swamps the growth of cat-tails is so luxuriant that they are cut and prepared for use in tight cooperage.

Moss litter. In sphagnum swamps two kinds of peat are generally recognized, the light, fibrous, undecomposed upper layers known as fibrous peat and the compact, pulpy lower layers which are more thoroughly decomposed and form the peat proper. The upper portion, which consists of matted roots and dead mosses and grasses, is often known as moss litter. Decomposition has not advanced to such a stage that the vegetable fibers have lost their strength; and, on account of its strength and property of absorbing large quantities of liquids and gases, it is extensively used in various industries both in this country and Europe. Usually the moss litter does not extend for more than two feet below the surface, though in swamps that are in colder climates the decomposition may never begin.

The principal purpose for which moss litter is used in this country is for packing trees and plants for shipment. The amount that is used in this way is very great, though the extent of its use is not realized because the gathering and preparation of the litter are not carried on as a regular industry, but each nurseryman sends his own men in slack times to the swamps to obtain the year's supply.

The preparation of the moss for this purpose consists merely in digging blocks of the material and air-drying them on the surface of the bog before hauling them away. When it is used for packing, it is pulled apart so as to make it light and fluffy. No particular care is used to get rid of the small sticks that may be present, though large pieces of wood are thrown out. In Sweden and Germany it has been used for some time in stables as bedding on account of its absorbing such large quantities of moisture and gases. It is now used to a slight extent for the same purpose in the larger cities of this country.

In several places in Canada this litter is prepared as an article of commerce, and in this case all the sticks are removed, and the moss is dried.

Peat fuel

The use of peat as an article of fuel has been known in European countries from the beginning of the Christian era, and the early references to its use would indicate that it had been employed for a long time before that. Pliny, in his *Natural History*, relates that "the Chauci pressed together with their hands a kind of mossy earth which they dried by the wind rather than the sun, and which they used not only for cooking their victuals, but also for warming their bodies." During the Middle Ages frequent references to its use were made in leases and other documents, but the great increase in its use came with the invention of the steam engine and the demand for cheap fuel for generating power. Up to that time the only use for peat and other fuel was for domestic purposes, and the method then used and still employed to a large extent in preparing peat for fuel consists of cutting

the peat from the bog in rectangular blocks and spreading these blocks on the surface of the bog to dry. When the greater part of the moisture is dried out, the blocks are stacked up like bricks, so that the wind has free access to all parts. When thoroughly air-dried, this fuel contains in many cases 20% of moisture, so that the full fuel value can not be obtained in burning it because of the amount of heat necessary to drive off the moisture.

Peat prepared in this manner, though ordinarily taken from the lower part of the deposit, is bulky and under the best conditions will not yield more than five ninths as much heat as is generated from the same weight of anthracite coal, which is about the same result as is obtained by the use of wood, as will be seen by reference to the following tables. These show in the columns marked A the number of pounds of lead reduced from litharge by 1 pound of the respective fuels and in the columns marked B the number of pounds of water raised from 32° F. to 212° F. by 1 pound of fuel.

	Partially dried Berthier		Containing 9% water Winhler		Perfectly dry Schodter and Peterson
	A	B	A	B	B
Oak	12.5	28.3	14.05	31.82	39.82
Ash	....	....	14.96	33.89	39.76
Sycamore	13.1	29.7	14.16	32.07	40.85
Beech	13.7	31	14	31.71	39.44
Birch	14	31.7	14.08	31.9	39.73
Elm	....	....	14.5	32.84	41.55
Poplar	....	....	13.04	29.54	40.72
Lime	....	....	14.48	32.8	41.87
Willow	....	....	13.1	29.67	39.61
Fir	14.5	32.8	13.86	31.39	41.25
Pine	13.7	31	13.88	31.44	40.82
Scotch fir	....	....	13.27	30.06	46.85
Hornbeam	12.5	28.3	.....	.....	.....
Alder	13.7	31	.....	.....	.....
Larch	....	....	.....	.....	41.25

	A	B	
Peat from Ham, dep't of Somme....	12.3	27.9	Berthier
" Possy, dep't of Marne.....	13	29.2	"
" Framont, dep't of Vosges..	15.4	34.9	"
" Königsbrunn, Wurtemburg	14.3	32.4	"
" Bog of Allen............	14.4	....	Cowper
" Bog of Allen, pressed.....	13.7	....	Everitt
Coppage turf	13	....	Kane's Indus. Resources of Ireland
Kilbeggan turf	14.2		
Kilbaha turf	13.8		
Peat from Ischomx	15.3	34.6	Berthier

	A	B	
Peat charcoal from Bog of Allen, upper....	27.7	....	Everitt
" Bog of Allen, lower.....	25	....	"
" Essone	22.4	50.7	Berthier
" Ham	18.4	41.7	"
" Seine	17.7	40.1	"
" Framont	26	58.9	"
Pennsylvania anthracite	30.5	69.1	"

In order to reduce the bulk and the amount of water, many machines have been invented for milling the peat. This does not increase the heating power of a given weight of peat that is free from water, but is useful in intensifying the heat and simplifying the transportation problem by reducing the bulk of the peat and the amount of water. Most of the peat that is used for manufactures in Europe is compressed, and many attempts have been made to introduce compressed peat into general use in the United States and Canada. Though peat briquets are cleaner than most fuels, their use must of necessity be limited to localities near the deposit on account of the expense of transportation. If, however, the peat is charred or coked, and the peat coke briquetted, we have a fuel which is nearly if not quite equal to anthracite coal, though

heretofore the expense of coking has been so great as to prevent its use.

Methods of preparing peat for fuel. The methods of cutting and preparing peat for fuel are many and varied, and the following description of the processes used is a condensation of articles by Percy, Mason, Dal and Carter.

Extraction of peat.[1] "Peat is usually of such consistency that when the bog in which it occurs admits of being suitably drained by the cutting of trenches or otherwise, or does not require artificial drainage at all, it can be extracted by hand with the use of simple and appropriate tools; and, for the most part, it has been so extracted from time immemorial.

"Peat, in being extracted by hand, is cut into prismatic pieces, which will be designated by the word peats. The superficial covering of living, or only slightly decomposed, coarsely fibrous vegetable matter must be pared off and thrown aside, as it is comparatively valueless for fuel. A straight trench with vertical sides, and a convenient length, breadth and depth, is dug in the parts so cleared, after which the peat may be cut from each side vertically downward, which is the usual course, or horizontally and parallel to the trench. The peats are carefully removed and arranged so that they may be gradually air-dried.

"It is obvious that the thinner peats are cut, the more quickly will they dry. It is stated that in Bavaria much of the peat there used for locomotives is less on an average than 2 inches in thickness."

Cutting peat by hand in Hanover.[2] The bog having been drained by simple trenching, "the peat is gotten in lengths 10 feet wide and from 100 to 1000 paces long, excavated crosswise, i. e. in the direction of the width, so that the working face is 10 feet broad. It is wholly extracted, either in one working or, if the bed be too thick for that method, in one or more successive courses. Usually only one length of the dimensions given is cut in a year from the same bog. Five workmen are employed, whose

[1] Percy, John. Metallurgy. p. 220.

[2] Percy, John. Metallurgy. p. 220–22.

labor is distributed as follows. One man, the clearer, removes with a spade, a layer about 2 inches thick, which has been weathered by atmospheric action. Two men, the cutters, are engaged in cutting the peat, of whom one stands on the top and thrusts straight down a long-handled, heavy, iron tool, which cuts sods 17 inches long and 5 wide, whilst the other, standing underneath, using a light wooden spade pointed with iron, cuts the peat horizontally of the thickness of 5½ inches and conveys it on a board to the margin of the trench; and from time to time these men change places with each other. A fourth man, the barrow-loader, takes the peats where they are left by the cutters, and, with the assistance of the first man, piles them in wheelbarrows. The fifth man, the barrow-wheeler, with the help of the first, wheels away the peats and by simply upsetting the barrow, arranges them in rows for draining and drying, over the surface of the bog on one side of the trench, previously cleared and prepared for that purpose. The peats, having been left for a certain length of time on the drying ground, are carried away by women and gradually built up by them in high wall-like rows, care being taken to let one row become somewhat dry before another is piled upon it. In ordinary weather the peats so arranged are left to dry further for about a month; and, when they appear to be dry, but when in reality they are only about half dry, they are either carted from the bog to be stored up in magazines or piled up in large stacks on the bog itself, and there left to be further air-dried."

Cutting peat by hand in Ireland.[1] In Ireland, the universal practice is to use a " slane " or peat spade. The cutting part is of wrought iron and the handle is about four feet long. " The peat is cut by thrusting the slane vertically downwards, by pressing the foot upon the lateral projecting piece of the handle. With a slane of this kind, an able-bodied man will cut about 15 cubic yards of peat daily. He cuts and flings as many peats as will keep two boys or girls employed in catching. The peats or sods are then put into barrows, and wheeled to the nearest convenient spot where they may be placed to dry."

[1] Percy, John. Metallurgy. p. 224.

Brosowsky's peat-cutting machine.[1] "In North Prussia a peat-cutting machine has been employed which has the great advantage of being able to cut and raise the peat from a depth of 20 feet or more: by means of which, peat, covered by a considerable depth of water, may be utilized without the expense of draining. It consists essentially of a cutter, made like the four sides of a box, but with oblique edges, which is forced down into the peat to the required depth. A spadelike blade is then driven under the cutter by means of levers, whereby the long rectangular prism of peat is cut off at the bottom, and the apparatus is then raised. The prism is afterward cut up into convenient sized blocks by means of the blade."

French peat-cutting machine.[2] A machine, having the same object as that of Brosowsky, is stated to have been invented in France about the middle of the 18th century by Eloi Morel. Other machines are used in France but the author has been unable to secure a good description of them.

Dredging peat. In some localities where the peat is in a more or less mudlike state, so that it will not hold together when dug by hand or machine, dredging machines have been used. In Holland the peat has been dredged in bags fastened to iron rings, so that the water will drain through the bags, after which the partially drained mass is laid on drying ground to become thoroughly air-dried.

Mechanical treatment of peat.[3] Common peat, when cut from the bog either by hand or by machine, is so tender and easily broken that it will not bear shipment to any distance. Even if it had the necessary coherence, it is so bulky compared with coal, that its use would compel the construction of larger and more costly furnaces in case it were used for metallurgic purposes. Many attempts have been made to obviate the difficulties which

[1] Percy, John. Metallurgy. p. 225.
Dingler's Polytechnisches Journal. 1865. 176: 336.
[2] Percy, John. Metallurgy. p. 226.
[3] Percy, John. Metallurgy. p. 227–29.

ordinary air-dried peat presents, and the principal methods employed may be classified as follows: (1) condensation of raw peat by compression; (2) condensation of air-dried peat, cold, by compression; (3) condensation of air-dried peat, hot, by compression; (4) condensation of raw peat by pulping, molding and air-drying or drying by artificial heat, with or without compression; (5) coking.

1 *Condensation of raw peat by compression*[1]

Many presses for the compression of raw peat have been constructed from time to time, but they have generally proved failures from an economic point of view.

"The earliest kind of machine for compressing raw peat, that is, peat as it comes wet from turbary, was very simple and consisted of a rectangular frame fitted with a flat piston which might be strongly depressed by a lever or otherwise, provision being made for the escape of water from the peat during its compression. A patent was granted in 1839 to Lord Willoughby de Eresby for a machine constructed on that principle.[2]" It is reported that Pernitzsch compressed peat in Saxony so long ago as 1821.

Schafhäutl's press with rotary motion.[3] "The first peat-compressing machine with rotary motion was said to have been invented by Schafhäutl. Compression was effected by placing the peat in frames fixed on an endless chain passing between a pair of rolls, set a certain distance apart, grooved rectangularly in the direction of their axes, which were horizontal and in the same vertical plane."

Compression by rolling.[4] About 1860, loose textured fibrous peat was reduced to about one third its original bulk by being passed through iron rolls at Neustadt in Hanover. Before roll-

[1] Percy, John. Metallurgy. p. 230.
[2] Johnson, S. W. Peat and its Uses. p. 116.
[3] Percy, John. Metallurgy. p. 230.
Vogel, August. Der Torf etc. p. 80.
[4] Johnson, S. W. Peat and its Uses. p. 119.
Percy, John. Metallurgy. p. 237.

ing, the peat was cut into sods of uniform size, and the product burned much more regularly than air-dried peat.

Mannhardt and Koch's press.[1] "The principal feature" of Mannhardt and Koch's press, "consists in the use of a pair of large horizontal rolls covered with cloth to serve as a filter. On the circumference of the roll, ribs of hoop iron are fixed obliquely about 1 inch apart, which support drilled iron plates surrounded by an endless band of cloth. The wet peat is torn to pieces and put into two hoppers, one over each roll, whence it is drawn by rake rollers and laid equally upon the cloths moving with the rollers; but in its course to the large rolls, it passes through a series of three small rolls, fixed above each large roll, whereby it is deprived of most of its water. There are thus two streams of peat descending from the two hoppers and passing first through a pair of small rolls, then through a pair of spiked rolls, and lastly through the two large rolls, by which the remaining water is pressed through the remaining filter cloth into the interior of these rolls. The peat now forms a compact sheet, which is conveyed to a knife-like apparatus, which divides it transversely, and then to circular cutters, which divide it longitudinally into blocks of the required dimensions. The peat is thus freed from water to such an extent that its further desiccation may be effected in favorable weather in the course of a few days under covered airy sheds, or in unfavorable weather, by artificial heat in suitable apparatus."

2 Condensation of air-dried peat, cold, by compression[2]

About 1859 a process of condensing air-dried peat was in vogue in Lithuania, which consisted in disintegrating and air-drying the peat by plowing and harrowing the surface of the bog, after which the pulverized peat was rammed in a mold by a stamp weighing about 200 pounds. This process does not seem to have been generally adopted and may be considered as an experiment so far as the preparation of fuel on a large scale is concerned.

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[1] Percy, John. Metallurgy. p. 231.
Vogel, August. Der Torf etc. p. 81.

[2] Percy, John. Metallurgy. p.232.

3 Condensation of air-dried peat, hot, by compression

Exter's process.[1] "This process, it is asserted, has been brought to the highest degree of perfection in a large and costly establishment between Munich and Augsburg where there is an extensive range of peaty moorland known as Haspelmoor. The moor is worked in rectangular plots 3000 feet long and 1500 feet broad, which are pared and then flattened, so that the water may drain from the center toward each of the four sides of the plot into the surrounding trenches, care being taken that no depressions are left in which rainwater might collect and form puddles. The surface is plowed to a depth of 2 or 3 inches, and the peat so turned up is disintegrated by raking it over two or three times with wooden rakes. In sunny and windy weather the peat becomes so dry that in the course of two or three hours it will no longer cohere by pressure, though it still retains from 30% to 40% of water; and, when sufficiently dry, it is heaped together in small stacks, to be ready for conveyance to magazines near the works. When brought to the mill, the peat is put into a bolting machine. The fine peat drops through, while the coarse, which consists of lumps and pieces of wood, falls out at the lower end and is used as fuel for raising steam. The fine material is heated to 100 degrees C., and pressed while hot into blocks. The press consists essentially of a box open at both ends, of the same form and area in cross-section as the largest side of a peat block and is fitted with a piston which is moved horizontally by means of an eccentric. When the piston is withdrawn to the fullest extent, hot peat drops into a channel between the piston and the mouth of the box and is pushed into the box and compressed by the forward movement of the piston, block after block being quickly formed and thrust out at the opposite end of the box."

4 Condensation of raw peat by pulping, molding and air-drying or drying by artificial heat, with or without compression

Challeton's process.[2] "Works for carrying out this process were erected in 1854 by M. Challeton at Montauger near Corbeil.

[1] Percy, John. Metallurgy. p. 233–36.
[2] Percy, John. Metallurgy. p. 237–40.

The peat, which is extracted by cutting or dredging, is conveyed to the works in boats by canals in the turbary and put into a tank lined with boards and deepening at the bottom toward the center. The peat is thence raised by a chain of buckets to the hopper of the dividing apparatus, which consists of a series of cylinders 4 feet long, but differing in diameter, fitted with knives 4 inches long and 1½ inches thick. These cylinders rotate and tear up the peat, which is next ground in a mill with conical surfaces like a coffee mill, after the addition of sufficient water. Between the cylinders and the conical mill is a sieve with brushing apparatus which retains filaments and grosser particles and allows the rest of the peat, now in a mudlike state, to pass through. The muddy liquid falls into tanks, where it is agitated by a shaft carrying arms, while a stream of water keeps flowing in at the bottom, and the muddy mixture is removed to a certain depth from the surface by a chain of buckets and poured into a wooden trough communicating with filtering tanks. Heavy materials such as sand, fall to the bottom during the agitation and are thrown away." After four or five hours, most of the water is removed from the peat in the filtering tanks, and the soft material can then be divided into blocks in exactly the same manner as in the original bog.

Weber's process.[1] At the works of Maffei & Weber at Staltach in Bavaria, "the peat is cut in pieces of about a cubic foot, worked into pulp, molded without compression into brick-shape pieces, or bricks, as they are termed, and dried under cover, first by simple exposure to the air, but afterwards by artificial heat. A gradual contraction in drying gives the peat the aspect of compressed peat and it is in no wise inferior to it, either in tenacity or compactness.

The peat is reduced to homogeneous pulp in a mill consisting of a vertical, sheet-iron cylinder, 4 feet high and 3 feet in diameter, open at the top, in which rotates a vertical shaft carrying eight blades. The blades are curved, triangular in cross section,

[1] Percy, John. Metallurgy. p. 240–44.
Dingler's Polytechnisches Journal. 153 : 272–86.

and sharp at the convex edges for the purpose of cutting the peat. When the peat is too dry for pulping, water is added. Pulping in this process is effected by cutting and not by rubbing, as in Challeton's machine.

"The pulp is molded either in molds such as are used for making mud brick, or the pulp is put into pits where the water drains off, and the peat is then cut into the required dimensions. After being either molded or cut, the peats are air-dried and then desiccated in a large building by artificial heat."

Linning's process.[1] In 1837 a patent was granted to Linning "for the preparation of peat by pulping, compressing and molding." The pulping was accomplished in a pug mill similar to those used in making brick, but fitted with longer and sharper knives. The peat was then molded like brick and pressed, after which they were dried either in the air or in kilns.

Buckland's peat machine.[2] This machine "consisted of an obtuse iron cone having a spiral groove on its exterior and revolving vertically and concentrically with the apex downward within a hollow cone of iron plate perforated everywhere with small holes like a colander. The peat was put into the space between the solid and hollow cone and, by the rotation of the former, was squeezed through the holes in the latter and extruded in the form of wormlike pieces; as prepared, it was ready for molding, and compressed peat bricks were artificially dried."

Schlickeysen's peat machine.[3] This machine has been used in Germany since about 1860 and with its many improvements is probably used more at the present day than any other one machine. "The peat is pulped in a vertical cylinder, in the axis of which a shaft rotates carrying projecting blades which are strong and have cutting edges, and are so placed as to force down the peat. The blades are arranged nearly but not exactly, in a true spiral, the effect of which is that they act unequally on the

[1] Percy, John. Metallurgy. p. 244.

[2] Percy, John. Metallurgy. p. 245.

[3] Dingler's Polytechnisches Journal. 1862. 165:184 and 1864. 172:333.
Percy, John. Metallurgy. p. 245–46.
Johnson, S. W. Peat and its Uses. p. 144.

mass and mix and divide it more perfectly. There are no blades or projections fixed to the internal surface of the cylinder. The pulp is driven out sideways through one or more nozzles inserted close to the bottom of the cylinder and issues in the form of a continuous block or pipe, that is cut off in suitable lengths either by hand or by machine. The addition of water is unnecessary in any case, indeed the pulp may with advantage be previously air-dried."

Leavitt's peat-condensing and molding mill.[1] About 1867, Mr T. H. Leavitt, of Boston Mass., took out a patent on a peat-condensing mill which consisted "principally of a strong box or cistern 3 feet in diameter and 6 feet high." The upper portion of the box is divided by a series of horizontal partitions, the upper ones being open latticework and the lower ones being perforated with numerous holes. The upright shaft which rotates in the center of the box, carries a series of arms or blades extending on opposite sides, and, as these revolve, they cut the peat and force it through the opening in the diaphragms. The lower portion of the box, in place of complete partitions, has a series of corrugated shelves extending alternately from opposite sides, and the peat is pressed and scraped from these by a series of arms. By this series of operations the air bubbles are expelled from the peat, and it is reduced to a homogeneous paste. When it arrives at the bottom of the box, it is still further compressed by the converging sides of the hopper, and it is received in light molds which are carried on an endless belt. Powdered peat is used for preventing the prepared peat from adhering to the mold. This prepared peat is then air-dried and is fit for use after about 10 days.

Hodge's method.[2] About 1866, a method of digging and preparing peat was devised by Mr Hodges in Canada. The plant consisted essentially of a barge, on which was all the machinery

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[1] Leavitt, T. H. Facts about Peat. p. 60.
Percy, John. Metallurgy. p. 246.
Johnson, S. W. Peat and its Uses. p. 146.

[2] Geol. of Canada. 1866.
Percy, John. Metallurgy. p. 247–57.

for digging and preparing the fuel. At one end of the barge were two screw augers, 11 feet in diameter, which bored out the peat in precisely the same manner as a common auger bores wood. The peat was then delivered into the barge and elevated to a hopper, from which it passed to a machine which removed all sticks and stones and reduced the peat to a pulpy mass. The pulp was then conveyed by a long spout to the surface of the bog, where most of the water drained out; when sufficiently dry, the mass was divided into blocks and stacked up to be removed, when thoroughly air-dried, to market.

Desiccation of peat.[1] The desiccation of peat is a subject which requires special consideration because of the difficulty of removing water by artificial means. Thoroughly air-dried peat contains not less than one fourth of its weight of hygroscopic water, which during combustion must be evaporated, thus causing a great loss in heat. When wet peat is exposed to artificial heat, the exterior dries into a hard crust which impedes desiccation and causes the mass to become fissured. When peat has been thoroughly dried, if it is exposed to the air, it will absorb so much moisture in a short time that it will be in no respect better than air-dried peat. Among the various methods for drying peat, may be mentioned those of Ekman and Welkner.

Kilns of a type similar to the one described below are reported to have been used in Carinthia and Hanover. It consisted of a chamber rectangular in plan, of which the walls were vertical and the roof arched. About one fourth of the hight from the bottom, was divided horizontally into two compartments by an arched floor, the upper compartment being intended to receive the peat, and the lower one to supply heated air. This lower compartment was connected with an adjoining fireplace on the outside of the chamber. In the wall forming the side of the chamber, opposite the fireplace, was a vertical chimney with a damper at the top which exceeded the hight of the kiln and communicated with the upper chamber. The floor between the upper and lower chambers was perforated so as to permit gases to pass through

[1] Percy, John. Metallurgy. p. 254.

the peat stacked in the upper chamber and the opening from this chamber to the chimney permitted the escape of these gases and the moisture which was driven from the peat.[1]

Ekman's peat kiln.[2] This kiln was a model of Schlägel's and consisted briefly of a chamber of rectangular cross-section carrying a horizontal trellis work on which the peats were placed. The kiln was heated by the waste gas of an iron finery using charcoal as fuel, the blast from which first passed through a spark chamber and then was admitted into the kiln through an opening near the top. The dried peat was withdrawn through doors at the bottom. The flow of the heated gases was induced by an exhaust fan communicating with the bottom of the kiln.

Welkner's peat kiln.[3] An apparatus for drying wood, lignite, brown coal and peat by the application of hot blasts, was invented by Carl Welkner. "The apparatus is under cover and supported by four brackets inserted in brick pillars. When the hot blast is let on, the bottom being closed, it descends through openings, and then rises through the mass of overlying peat. The drying goes on interruptedly, fresh peat being put in at the top as fast as dried peat is taken out at the bottom, where it is obvious the peat must be driest."

Desiccation of peat by centrifugal action.[4] Many experiments have been made to dry the peat by centrifugal action, the theory being that the water would be thrown off and the peat retained in the machine. In practice it has been found that, except in very coarse, fibrous peat, the loss of peat was too great, as the fine material passes through the holes intended for the escape of the water.

5 *Peat charcoal or coke*[5]

Charcoal prepared from peat in the same manner as is employed in manufacturing wood charcoal is so friable and porous

[1] Percy, John. Metallurgy. p. 255.
[2] Percy, John. Metallurgy. p. 258–61.
[3] Percy, John. Metallurgy. p. 262.
[4] Percy, John. Metallurgy. p. 263.
[5] Percy, John. Metallurgy. p. 498–501.

as to be of little use in manufacturing. It takes fire very readily and scintillates in a remarkable degree when burnt in a smith's fire, but it is so tender that it can not be transported to any distance without being reduced to powder. On this account, it is useless for blast furnaces where ordinary wood charcoal may be used, as the weight of the mass pulverizes the coke and chokes the fire.

For two or three centuries, many attempts have been made to char peat, and it is recorded that peat charcoal was made in the Harz in 1735 and successfully applied on a large scale. The earliest English patent for charring peat was granted in 1620 to Sir William St John, Sir Giles Mompesson and others, giving them the exclusive right "to charke or otherwise to converte into charkcole" every kind of coal, peat or other "combustable matter of what nature or qualetie soever the same may be, (wood onelie excepted)" for a period of 21 years. As no method of charring is specified, it is to be presumed that it was proposed to treat the peat in the same manner as wood when it is charred. About 1727 a patent was granted to William Fallowfield for the use of charred peat in the manufacture of iron.

Many experiments have been made in charring peat with the method commonly used for charring wood, but the result has always been a very friable coke.

Charring in open kilns.[1] About the middle of the 18th century, kilns of peculiar type were in use at the turbaries of Villeroi for making peat charcoal. "They were in the form of an inverted cone, on one side of which was a door about 5 feet high and 2 feet wide. Near the base of the cone an arched floor with holes in it for passage of air supported the peat, while underneath the little fire necessary for igniting the peat was placed. When the peat is sufficiently lighted, the opening communicating with the external air is closed, and the doorway built up with brick." After the kiln had been filled with peat, it was covered with earth and left to burn; gradually the whole mass would sink

[1] Percy, John. Metallurgy. p. 501.

down, and, when no more smoke appeared, the charring was completed.

Charring in pits.[1] Peat has been charred in pits in much the same way as the Chinese process of making wood charcoal. The invention of the method as applied to peat is attributed to a Frenchman named Baillet. "The pit is described as slightly conic, 3 meters deep and 4 meters wide. Around the circumference, which is of brick, eight clay pipes lead to the bottom for supplying air to sustain combustion. The pit is closed by a movable, convex cover of sheet iron, like a common dish cover. On top is a hole fitted with a movable iron stopper, and there are four vents around the border. Below the surface of the ground, there is a pipe communicating with the upper part of the pit and with a brick tank connected with a series of vessels for the reception of tar or other condensable products. The smoke is driven through this pipe only when these products are being collected, at other times escaping through the vents in the top. The pit was filled by first leaving channels at the bottom, so that air might reach all parts equally, but after the bottom arches were formed, the peat was thrown in without particular care. After the peat was ignited, the cover was dropped over the pit and was itself covered with sod." The vents were opened at times depending on the nature of the smoke which was passing off.

Charring in ovens.[2] The friable nature of charred peat as prepared by any of the preceding methods, was attributed to defects in the method of preparing. It was supposed that, by inclosing the peat in a solid structure, these disadvantages would be avoided and a solid charcoal obtained. Various kinds of ovens were contrived from time to time to bring about the desired result, and it is stated that the first oven was invented by Lange, about 1745. This oven "consists of a chamber of iron cylindri-

[1] Percy, John. Metallurgy. p. 502.

[2] Percy, John. Metallurgy. p. 503 *et sequens.*

Percy, John. Metallurgy. p. 505.

Vogel, August. Der Torf, seiner Natur und Bedeutung. p. 117–19.

cal to about two-thirds its hight and conical the upper third. It rests upon an iron bed plate containing a rectangular opening over which iron bars are laid to form a grate. The bed plate rests upon a chamber of brickwork open at the top and in front, where it can be closed by a door; the floor of the chamber is inclined from back to front. This chamber is intended for a fireplace for wood fuel. Peats are carefully laid over the grate so as not to stop the draft upwards from the fireplace. The kiln is then filled through the top and wood fire is made in the fireplace. After the peat becomes well ignited, the fireplace is closed by an iron door. The peat gradually becomes heated to redness and shrinks about one-third in volume, fresh peat is now thrown in at the top, and this course is repeated until the entire contents of the kiln become red-hot. As soon as smoke ceases to escape, the top is covered with an iron plate and the contents of the kiln are allowed to cool." Charcoal made in this way however is found to be very brittle, and there is great loss owing to combustion of the lower part and the formation of much dust and slack.

An oven for charring peat by a down draft rather than by upward draft, was invented by Hahnemann. This oven consisted of a circular shaft of brick or stone work 16 feet high and 7 feet in diameter in the clear. The walls gradually diminish in thickness from 2 feet at the bottom to 10 inches at the top. The shaft rests upon a solid foundation, the floor is somewhat arched with a convexity upwards, and on one side is an opening for withdrawing the charcoal. In the circumference of the floor is a gutter of glazed tiles, from which a glazed clay pipe passes with a slight inclination downwards through the wall and communicates with a tank for the reception of any liquid which may be condensed. On the middle of the floor stands a vertical clay pipe glazed internally, 19 feet high and 16 inches wide, and in which, near and around its base, are several holes, the total area of which should at least equal the cross-section of the pipe. Before charging, the opening at the bottom of the

oven is filled up, then the shaft is filled with peats and on the top are laid twigs and charcoal which are lighted. When the peats at the top become regularly kindled, the open space around the chimney is closed, so that the smoke is compelled to descend through the peat and pass into the chimney near its base and thence rise into the atmosphere; as soon as the contents have become red-hot at the bottom of the shaft, all openings are carefully closed and luted and the oven is left to cool."

Charring in closed vessels by external fire.[1] About 1873, a coke oven, or rather a still, was invented by Lottmann of Chlumetz in Bohemia. The oven consisted of "an arched mufflelike chamber heated by two fires, one on each side, and by a third fire at one end under the floor. The central fireplace opens into a flue running under the floor to the chimney at the opposite end of the oven. In the top of this flue are inserted two siphonlike sets of cast iron pipes, of which the legs are parallel and which rise within the oven to about half its hight. Midway between the legs of each of these sets of pipes, the flue is stopped by a vertical partition, by means of which the gases from the fireplace are made to pass in their course to the chimney through all the four legs of the two siphon-like sets of pipe in succession. Provision is made for collecting liquid products evolved from the peat during its carbonization. The peat which is charred in this oven is hand-cut, air-dried peat."[2]

Manufacture of peat fuel in Canada[3]

Two methods of preparing peat fuel are at present in use in Canada, which are in reality but two applications of the same process. This process as described by Carter and termed by him "the Canadian process," consists of three steps, excavating, drying and compressing. At the Welland bog, a modification of

[1] Reports on the Vienna Universal Exhibition in 1873; presented to both houses of Parliament. Lond. 1874. pt 2, p. 308–10. Report on peat by Mr C. Paget.

[2] Percy, John. Metallurgy. p. 508.

[3] Carter, W. E. H. Peat Fuel: its Manufacture and Use. Ontario Bureau of Mines. Bul. 5. Toronto 1903. p. 23–35.

Exter's process is employed, which consists of plowing or harrowing the surface of the bog to the depth of about 2 inches and, when the peat has become air-dried, scraping it into ridges and then conveying in carts or cars to the mill. At the mill the peat is screened, then put through a mechanical drier, after which it is disintegrated and conveyed to the briquet machine. This press, which was patented by A. A. Dickson, depends on the principle "that, if a tube of indefinite length be fed with any material, the resistance due to friction between the material and tube walls, will gradually rise till no more can be forced in. Peat is of such a nature that, when once caused to pack in the tube, continued pressure on the material generates a rapid and great increase in the frictional resistance. For a die or tube 2½ inches in diameter a length of 1 foot will give a frictional resistance equal to a pressure of 8 tons per square inch on the punch." Difficulty has been encountered at the Welland plant from heating the die, and water jackets have been used to keep the tubes cool. The continued use of similar processes of briquetting peat in Russia, Germany and Holland, makes the difficulties here encountered seem somewhat surprising.

At the Beaverton works, the peat is excavated by a machine known as the Dobson excavator, which digs the peat and spreads it over the surface of the bog to dry. The peat is raked by hand and scraped into piles in about the same manner as at the Welland bog, after which it is taken to the mill. On reaching the mill, it is passed through a "disintegrating machine, where it is subjected to a fierce hail of blows in order to reduce the size of the fragments and destroy the minute plant cells of the peat fiber, thus permitting the remaining moisture to be more readily liberated in the drier. The machine consists of a circular sheet iron box incasing a horizontal shaft from which project radial cast iron arms about 1 foot in length; through the ends of these and parallel to the shaft, run iron rods, each suspending a roll of knob-like, cast steel fingers, 4 inches long and free to swing about the rod. The shaft makes 400 revolutions per minute, and the steel fingers, flying out radially, dash the peat fragments against a

semicircular grizzly set close beneath. Through the one-sixteenth-inch spaces of this grating, the peat drops as a mixture of fine particles and dust, damp to the touch." The pulverized peat is then passed through the drier, after which it is briquetted in what is known as the Dobson press. This press employs a resistance block instead of the open tube, and it is claimed that friction is almost entirely eliminated. A large number of dies are used with each punch, so that the temperature is kept low. "The briquet is allowed to remain in the die for one cycle of the system and is then subjected to another compression by a second briquet being formed on top of it. Immediately after this, it is expelled and the second block takes its place. It is found after the first compression, a certain amount of expansion, about one-eighth of an inch in the length of the briquet, takes place, due to the escaping of the imprisoned air forced into the briquet by the descending punch, and this expansion the second compression counteracts, leaving the briquet more solid and compact. There are two punches in each machine, and for each punch a die block containing eight snugly fitting dies. The dies are heavier in the lower end where the compression takes place. The base block against which the briquets are formed, remains rigid unless for any reason the strain exceeds the working pressure, when a set of spiral steel springs on which the block rests take up excess pressure and prevent any breakage. The down-thrust of the punches is imparted by two heavy eccentrics faced with roller bearings, and with each stroke of the punch the die block is turned through one eighth of a revolution. Working in the next die to the compressing punch is the releasing punch, which expels the finished briquet, while the third receives an oil swab, which coats the inside of the die with a film of crude petroleum to lessen the friction and facilitate the expulsion of the briquet. The two punch system of the press acts reciprocally, a stroke being delivered at every half revolution of the eccentric shaft. With each down stroke, the compressing punch forms a briquet on top of the one previously made in the same die, the discharging punch expels from the next die the bottom or com-

pleted briquet, the third die receives its coating of oil from the oil swab. Power is transmitted through belting to a pulley on the pinion shaft and thence by a 5 foot gear wheel operating the eccentric shaft. The machine is steadied by a heavy fly wheel on each of these two shafts and runs quietly and with little vibration, notwithstanding the immense and sudden pressure exerted twice every revolution. It makes 50 or 51 revolutions per minute, producing 100 or 102 briquets."

Peat coke and volatile products

A plant[1] recently installed in Oldenburg, Germany, seems to solve the problem of coking peat economically. This is the invention of Martin Ziegler and is a modification of Lottmann's process. The plant consists of five kilns, in which from 10 to 12 tons of peat are coked in 24 hours, 3 tons of peat giving on an average 1 ton of coke. All volatile matter is driven out, and the coke burns without flame. The gases from the peat are utilized not only for heating the kilns but for supplying the boiler of a steam plant with fuel.

In coking the peat, oil and ammonia are driven off in addition to the gas, which is used as fuel, and they are saved and sold. If such a coking plant were run in connection with a gas plant, all the volatile matter could be used to advantage, and peat coke could be made with greater economy.

The following extract from Consular Report 1615[2] contains a description of the Ziegler method:

Concisely stated, the Ziegler method consists in carbonizing peat in closed ovens, heated by burning under them the gases generated by the coking process itself. Such a plant is therefore self-sustaining, the only fuel required being coal or wood sufficient to heat the oven for the first charge, when the gases generated by the coking process become available and enable the operation to be repeated and continued indefinitely. Not only this, but the offheat from the retort furnaces passes on and heats the drying chambers, in which the raw, wet peat is pre-

[1] Dal, Adolf. Utilization of Peat Fuel in Europe. Eng. Mag. Nov. 1902.
[2] U. S. Department of State. Consular Report 1615. Ap. 8, 1903. p. 6–7.

pared for the ovens by drying to the point of economical carbonization. There is transmitted to the department as an exhibit with this report a sample of 1 kilogram (1000 grams, or 2.2 pounds) of raw peat, and the several products derived therefrom by the Ziegler process, each in its due proportion, as follows: Three hundred and fifty grams of coke, 40 grams of tar, and 400 grams of gas liquor, from which last is derived 6 grams of methyl alcohol, 6 grams of acetate of lime, and 4 grams of sulfate of ammonia. If this sample be multiplied a thousand fold to a metric ton, and the value of each product given at its present market price in Germany, the demonstration would be as follows:

Description	Value	
1 ton (1000 kilograms) of peat, costing, dried, 5 marks ($1.19), produces:	Marks	
350 kilograms (771.6 pounds) of peat coke.	15.75	$3.75
40 kilograms (88.2 pounds) of tar.........	2.20	.52
6 kilograms (13.2 pounds) of methyl alcohol	4.20	1
6 kilograms (13.2 pounds) of acetate of lime	.72	.17
4 kilograms (8.8 pounds) of sulfate of ammonia	.88	.21
Total	23.75	$5.65

The peat coke produced as the primary product of this process is jet black, resonant, firm, and columnar in structure, pure as charcoal from phosphorus or sulfur, and, having a thermal value of from 6776 to 7042 calories, it is so highly prized as a fuel for smelting foundry iron, copper refining, and other metallurgical purposes that it readily commands from 40 to 50 marks ($9.52 to $11.90) per ton. It is also a high class fuel for smelting iron ores, but, as the process is comparatively new and the output limited, it is as yet too scarce and expensive for blast furnace purposes. Crushed and graded to chestnut size, it forms an excellent substitute for anthracite in base-burning stoves. In larger lumps, as it comes from the oven, it fulfils substantially all the various uses of wood charcoal as a clean, smokeless fuel. The cost of a four oven plant, with all apparatus for cutting and drying the peat, distilling the gas liquor and extracting paraffin from the tar, is given at $95,200. Such a plant is reckoned capable of working up annually 15,000 tons of peat, the various products of which would sell, at present wholesale

market prices, for 494,100 marks ($117,596). A plant of 12 ovens, with all appurtenances complete, would cost $261,800 in Germany, and should produce annually products worth $350,000, from which, deducting the carefully estimated cost of peat, labor, depreciation of property and other expenses—$179,200—there would remain a profit on the year's operation of $170,800. This process is in successful operation at Redkino, in Russia, and the German government has evinced its practical interest in the subject by placing at the disposal of the company a large tract of peat-moor lands, the property of the state, on which extensive works will be erected during the coming year.

The products that may be produced by such coking are many and valuable, and it is a question whether the by-products may not prove more valuable than the coke. A list of these include ammonia, ethyl alcohol, methyl alcohol, acetic acid, benzol, illuminating oils, paraffin, tar and heavy lubricating oils. With the exception of the ammonia, all these products can be used in the generation of gas if desirable, though ordinarily it would probably be more desirable to save each product.

Among the other uses for which peat has been employed may be mentioned the construction of pavements and the manufacture of paper and a substitute for terra cotta and papier-mâché, while carpets, celluloid and antiseptic bandages may be added to the list. It has also been employed to a slight extent in tanning. As a filtering agent peat charcoal is said to be superior to any other, and it is also said to be unsurpassed for use in the manufacture of powder for fireworks.

Agricultural value of peat

In the United States the way in which peat has been most extensively employed is in its character of swamp soil and as a fertilizer. The ordinary practice in using the swamp soil is to drain the swamp with ditches about 3 feet deep at suitable intervals, clear the surface of the woods and burn the stumps and loose cap of leaves or moss, after which the land is plowed. The application of a dressing of lime is beneficial in neutralizing the acidity of the peat. In this way a soil is prepared which is unexcelled for raising vegetables and nearly all crops except grain.

Many upland soils are improved[1] by the application of a dressing of peat or a compost of peat and stable manure, and the benefits derived come from two causes (1) its action in improving the texture and other physical qualities of the soil and (2) its direct fertilizing value.

The value of peat in improving the texture of the soil depends on (1) its powers of absorbing and retaining water; (2) its power of absorbing ammonia; (3) its effect in dissolving mineral matters; and (4) its effect on the temperature of the soil. Its value as direct fertilizer depends on some of the organic matter present, particularly ammonia and the small amount of potash, phosphoric acid and lime present. As these direct fertilizing ingredients rarely form 2% of the entire mass when free from water, it will readily be seen that the material as taken from the swamp need not be looked on as a source of supply for mineral fertilizers. In fact, where swamp soils give the best results, large amounts of commercial fertilizers are added, so that the value of peat as a direct fertilizer is almost nothing. The action of the organic acids present in peat is unknown; and it may be that some of these have a decided fertilizing effect, but the probability is that they have no fertilizing value, for ordinary crops can not be raised till these acids have been rendered insoluble.

The principal benefits arising from the application of peat to soils come from its mechanical effect, which makes light soils more retentive of moisture and ammonia and lightens clay soils.

Associated products

Marl. In many swamps, just beneath the peat, is a deposit of shell marl. This material, which is nearly pure carbonate of lime, is used extensively in the manufacture of Portland cement and lime. It is used instead of marble dust as a source of carbonic acid for use in charging soda water and other carbonated waters. Frequently the marl and peat are interstratified, in

[1] Johnson, S. W. Essays on Peat, Muck and Commercial Manures.

which case the marl usually predominates in the lower strata and the peat in the upper strata.

Clay. The deposits of clay that underlie many swamps are of great value when accompanied by marl, with which it is mixed to make Portland cement.

Infusorial earth. In the open waters near the center of many bogs certain low grade plants and animals called diatoms and infusoriae respectively develop and add their remains to the bog accumulations. These plants and animals are composed largely of silica, and the remains form a deposit that is known by the various names of tripoli, infusorial earth and diatomaceous earth. Only two deposits of this material are known in this State, i. e., at White lake, Herkimer co., and Cold Spring Harbor, L. I., but careful prospecting will probably reveal other deposits in some of the large marshes. The principal purposes for which this material is employed are for heat insulation, metal polish and the manufacture of dynamite.

Bog iron ore. Another material that is likely to escape notice in ordinary prospecting is bog iron ore, which is found in many swamps just below the peat near the margin of the bog. The abundance of large supplies of better grades of iron ore prevent exploitation of these deposits, though many blast furnaces in Europe depend on this kind of ore for their supply. Many swamps in the Adirondacks contain large deposits of this material, and this seems to be the best locality in the State in which to look for this material, though it may be found in the swamps elsewhere.

PART 4

Distribution of swamps in New York State

With but few exceptions the large swamps are in those parts of the State that are approximately level. The salt marshes are found on the shores of Long Island, Staten Island, Manhattan Island and that part of Westchester county bordering on Long Island sound and the Harlem river, and the shores of the Hudson as far north as Newburg. A list of the marshes on Long Island and that part of Westchester county bordering on Long Island

sound is given below, together with the approximate area of each marsh.

Salt marshes of New York State[1]

Lat. ° ′	Long. ° ′	Locality	Area in acres
41.04	71.55	Great pond, end of Long Island	285
41	72.03	Napeague harbor	332
41.01	72.08	Acabomack	316
41.08	72.15	Oyster pond	886
41.06	72.22	About Stirling and Greenport	127
41.05	72.21	Derring's harbor	16
41.03	72.20	West Neck harbor	32
41.04	72.19	Coecle's harbor	32
41.01	72.12	Three-mile harbor	127
41.02	72.13	Ely's brook	79
41	72.22	Jessup's neck	32
40.56	72.26	Jessup's neck, large swamp	569
41	72.27	Cutchogue harbor	253
41.02	72.25	Great Hog neck, east side; two thirds water	300
41.02	72.25	Great Hog neck, west side	32
41.03	72.28	Goldsmith's inlet	16
41	72.35	Mattituck pond	47
40.59	72.37	Luce landing	16
40.55	72.37	Flanders, Riverhead, Aquebogue	2182
40.57	72.51	Wading river	142
40.58	*.59	Mount Sinai harbor	285
40.55	*.50	Stony Brook harbor and East Flats	474
40.53	*.48	Nissequague river	211
40.54	*.45	West of Nissequague river	206
40.56	*.41	Crab meadow	316
40.56	*.37	Northport bay	111
40.53	*.35	Huntington harbor	32
40.56	*.31	Meadow, Lloyd's point	32

[1] Shaler, N. S. Eastern Sea Coast Swamps. U. S. Geol. Sur. 6th An. Rep't. 3:394–98.

*Long. east of New York city hall.

Lat. ° ′	Long. ° ′	Locality	Area in acres
40.52	*.30	Oyster Bay harbor	79
40.54	*.26	Mill Neck creek	300
40.54	*.24	Fox island to Lattingtown	221
40.54	*.22	Dosoris pond	79
40.52	*.22	Mosquito cove	150
40.52	*.18	Prospect point	63
40.48	*.21	Roslyn	32
40.48	*.18	Head of Manhasset bay	127
40.46	*.15	Little Neck bay	237
40.49	*.12	Throg's neck	127
40.52	*.12	Hutchinson river; incomplete	601
40.53	*.12	Along the coast, Rodman to Davenport's neck	474
40.54	*.13	New Rochelle	95
40.55	*.15	Delancey cove	316
40.56	*.17	Mamaroneck	221
40.57	*.19	Mill creek	316
40.58	*.20	Manursing island	190
41	*.21	Port Chester	47
41.01	*1.49	Three mile harbor	63
41	*1.45	North West creek	316
41	*1.42	Sag Harbor	63
41	*1.39	Noyack	95
40.56	*1.35	Cow neck and North Sea harbor	490
40.54	*1.30	Canoe Place	79
40.54	*1.26	Southport	300
40.52	*1.28	Tiana	111
40.50	*1.25	Shinnecock bay, shores of	696
40.50	*1.25	Quoque	
40.47	1.17	Around Moriches bay	
		Petunk	491
		Between Petunk and Forge river	554
		Front beach, etc.	949
40.37	*.25	Hempstead bay	4064

*Long. east of New York city hall.

Lat. ° ′	Long. ° ′	Locality	Area in acres
40.36	*.28	South Oyster bay islands	1787
40.39	*.30	Shore (long. .27′ to .35′) and Great island	3116
40.37	*.31	Islands	996
40.37	*.34	Jones beach and adjacent islands	1755
40.41	*.40	Coast inside (long. .35′ to .45′)	1866
40.38	*.40	Oak Island beach and adjacent islands	2704
40.43	*.45	Long. .45′ to Connetquot brook	1487
40.39	*.49	Fire Island	253
40.43	*.53	Connetquot brook to Edward's landing	712
40.44	*.56	Brown's point	206
40.44	*.59	Blue point and Mill's landing	158
40.45	*.59	Patchogue landing	79
40.45	*1.02	Swan creek to Howell's point	474
40.46	*1.06	Bellport bay	886
40.45	*1.09	Smith's point to end of chart of southern coast of Long Island, western part	712
40.45	73.50	Flushing bay	1978
40.49	73.50	Westchester creek	538
40.49	73.51	Just west of Westchester creek	316
40.49	73.52	Bronx river	380
40.48	73.55	Mott Haven and Port Morris	601
40.46	73.54	Near Berrians island	253
40.44	73.57	Hunter's point	1218
40.36	73.47	Rockaway beach	459
40.37	73.50	Islands in Jamaica bay	3732
40.37	73.50	Coast around Jamaica Bay	11070
40.35	74	Coney Island	949

The marshes on the Hudson and Harlem rivers are not listed, but there is almost no break in the mud flat of the Harlem river from Mott Haven to Spuyten Duyvil, though the area of this marsh is not known.

Lists of the swamps in southeastern New York were prepared by Mather and Beck; but after 60 years it is difficult to locate

*Long. east of New York city hall.

many of the swamps. There are many reasons for this. In the first place most of these deposits were shallow, and many of them have been drained, so that the only trace of the former swamp is a deposit of black soil that may not be a foot in thickness. As an example of this, the marsh south of Stissing pond, Dutchess co., which was reported to be underlain by about 2 yards of peat and to cover an area of 500 acres, is at the present day a fertile valley with a black soil about a foot thick in most places. In one place a deposit of peat about 11 feet thick still exists; and it is possible that Mather may have found just such a pit as was found by the author, and that it misled him into thinking that the entire flat was covered to the same depth.

The Deuel swamp is another example of just such thinning out of a peat deposit. This swamp, which was reported by Professor Cassell to be about 150 acres in extent and underlain by about 6 feet of peat, is at present underlain by about 18 inches of black soil. I have no doubt that 60 years ago the deposit was 6 feet deep, but cattle have been pastured here, and their trampling has prevented the growth of the deposit and has caused the more rapid decomposition of the vegetable matter.

It would be difficult to find a spot in the entire State that is more than 10 miles from a swamp; and, though not all swamps furnish peat, yet it is within the limits of probability that peat will be found in at least half of them. The most extensive group of swamps is found in the Finger lake region and the lowlands near the St Lawrence river, though the largest swamp of all, the Drowned Lands of the Wallkill, is in the mountainous part of Orange county, which borders on New Jersey. Many peat deposits are found in the Adirondacks, and, as exploration is carried farther, the recorded number will be much greater. The depth of the Adirondack swamps is likely to be greater than that of most of the swamps in the central and western portions of the State, though the few visited by the author are not very deep.

I shall not attempt to give a list of the fresh-water swamps in the present work on account of the great number and the lack

of accurate information in regard to underlying deposits, but would refer the reader to the topographic atlas sheets of the United States Geological Survey for maps of the swamps that have been surveyed. The lists prepared by Beck and Mather have been frequently quoted and will be found in their reports for 1842 and 1843, respectively. They are also quoted by Leavitt[1] and Ries,[2] and the latter has added an incomplete list of swamps in the Adirondacks and central and western New York.

PART 5

Description of important swamps in New York State

Drowned lands of the Wallkill. Along the Wallkill river is the great swamp, known as the Drowned Lands of the Wallkill, which extends from Sussex N. J. to New Hampton N. Y.

The bog varies in width from less than a mile at the state line to 4 or 5 miles near Little island or Durandville. Several islands, made up principally of gravel and undoubtedly of glacial origin, lie within this tract. The principal ones are Pine island, Black Walnut island, Big island and Little island, though other smaller ones occur in various parts.

The main portion of the swamp is on the east side of the Wallkill, though on the west side there is a swamp deposit that in some places is nearly a mile wide. The north end of the swamp and most of that portion on the west side of the river have been pastured, so that natural conditions no longer exist. An extensive tract extending from Orange Farm to a point about 2 miles north of Pine island has been drained and is used for truck gardening, but by far the greater part of the swamp is in its natural condition.

The name Drowned Lands may possibly give a mistaken impression of the nature of the swamp, as one might imagine that the surface is covered with water and would therefore be almost, if not quite, inaccessible. This however is not at present the case, inasmuch as very few places are covered with water, and

[1] Facts about Peat. p. 124.

[2] Uses of Peat and its Occurrence in New York State. 21st Rep't of the State Geologist.

over the greater part of this swamp a forest of both deciduous and coniferous trees is growing. At times of high water, however, the swamp is covered with water, and in February 1903, a large portion was covered with ice.

On the forest floor is a dense carpet of mosses and liverworts, while tracts that have been burned over are covered with a dense copse of birch and poplar. In places where trees have been uprooted cat-tails and liverworts are the first plants to grow, but sphagnum moss and shrubbery soon take their part in restoring the original condition of affairs. The woodland between the river and Big island is made up principally of deciduous trees, though hemlock, pine and cedar grow here.

The woods near Pine island, on the other hand, are made up principally of cedars and tamaracks, and a moss of the genus Hypnum is the only one that forms any important part of the surface covering.

Near Black Walnut island the two types of vegetation seem to meet, and, as a result, the list of plants is larger, as most of the plants of the other sections are to be seen. In a tract of not more than 10 square rods the following ferns and mosses were found: *Osmunda cinnamomea, Dryopteris noveboracensis, Climacium* ———, *Dicranium undulatum, Strichum undulatum, Hypnum* ———, *Sphagnum* ———.

As would be expected from the topography of the region, the thickness of the peat varies from almost nothing to 18 feet or more. On the river bank at the north end of the swamp outcrops of peat are found which vary in thickness from less than a foot to 3 feet. This peat is dry and undoubtedly represents a deposit of wet peat several times the thickness of the dry material. Beneath this layer is a deposit of blue clay which sometimes contains leaf impressions. Sometimes a sandy marl intervenes between the peat and the clay. The surface rises gradually from the river bank, and a boring about 10 yards back showed peat to a depth of 5 feet. Where the marsh has been pastured, there is a black soil about a foot thick above the peat, and near the river

this is sometimes made up quite largely of a sand or clay sediment. In the wooded portion the thickness of the peat increases very rapidly, and about a half mile from the river the clay was not reached till 17 feet of good peat was bored through. The thickness of the deposit at various points is as follows:

Pine island	18 feet	bottom not reached
Black Walnut island	18 feet	"
½ m. west of Durandville	16 feet	clay underneath
1½ m. west of Durandville	17 feet	"
½ m. west of Big island	12½ feet	bottom not reached
1 m. west of Big island	12½ feet	"
Florida	18 feet	"

A fair average of the depth would probably be about 18 feet, though many places are reported, on questionable authority, to have a depth of 50 feet. The quality of the peat from the surface to the underlying clay is apparently very uniform. Except near the river bank, no sand is to be detected, and the clay beneath it is very fine grained. A slight amount of sand is to be noticed in the clay in some places, though ordinarily it is remarkably free from grit. The small quantity of marl present is somewhat surprising, as about 2 inches of marly peat just above the clay are the only trace of its existence. From the fact that all classes of vegetation are present on the surface of the deposit, and that borings bring up nothing but pulpy peat and decomposed wood from all depths, it is readily seen that there has been no great change in the general type of vegetation in this place since the lake-filling process started. So far as the materials which form the peat are concerned, this deposit would hardly come under any of the classes of peat deposits given by Wagner, but would be rather a composite deposit.

Because of the great thickness and the jellylike consistency of the deposit, the quaking of this bog is more pronounced than in shallower deposits, which are underlain by marl. When a carriage

passes trees near the roadside, the branches of trees may be seen to shake violently, and even the water in the drainage ditches rolls along in waves 1 or 2 inches high. The pulpy nature of the peat will be perceived when it is understood that a 2 inch auger may be pushed down to the clay, after the tough top layer is penetrated. The trunks of decayed trees seem to offer no resistance, being penetrated just as easily as the mass of peat formed from moss and leaves.

The soil on the drained portions is well adapted for nearly all crops except grain, though it is used almost entirely for raising garden truck. It is thought by some that it does not equal the soil of the Greycourt meadows, but this is very doubtful. It is quite likely, however, that lands which have been recently drained may not be so fertile as those which have been fertilized with lime and phosphate for some years, as the bog soil seems to be lacking in these elements.

The following table of analyses[1] shows the quality of the peat from the Drowned Lands.[2]

Test pit	Depth of sample	LOCALITY	Organic matter	Ash
1 A	1 ft down ..	West bank of river at highway bridge south of head of canal.	69	31
1 B	3 " ..		85	15
1 C	5 " ..		89	11
2 A	6 in. down..	1¾ m. n. 50° w. of Florida, about 300 feet from edge near house of Mr Powers.	49[a]	51
2 B	3 ft " ..		85[a]	15
3 A	14 in. " ..	At side of swamp road 1¼ miles n. 60° w. of Florida. About in center of that area of swamps.	78[a]	22
3 B	3½ ft " ..		87[a]	13
4 A	Surface soil	North side "Goshen turnpike," about ¾ mile southwest of Quaker creek, between Big and Black Walnut islands.	81	19
4 B	3½ ft down..		90	10
5 A	6 in. " .	North side of road, 150 feet west of Owen's Station, N. J.	90[a]	10
5 B	3½ ft " .		89[a]	11

[1] Analyzed by J. B. Gilmore, May 22, 1900.

[2] Freeman, John R. Report upon New York's Water Supply. N. Y. 1900. p. 520.

[a] Samples contain little or no iron.

The upturned roots of trees show how ill adapted the peat is for raising anything till it has been drained and the acidity neutralized. None of the trees show any taproots, and the tree derives its entire nourishment from the porous mass of moss and leaves on the surface. The roots are very wide spreading, so that a high wind is necessary to overturn a tree, but the roots have no hold on the subsoil.

Greycourt meadows. Between Chester station and Greycourt station are the Greycourt meadows, which embrace a tract of land estimated to be about 3000 acres. The entire marsh has been drained and is one of the most valuable tracts of farming or gardening land in the State. Near Chester, about 200 yards from the border of the flat, clay is found at a depth of 8 feet. Except for the top layer of soil, there is no perceptible difference in the character of the peat from the top to the bottom. The sample taken showed the same materials as the peat from the Drowned Lands.

Stissing pond. The formation of peat deposits by the filling of lakes is well shown on the margin of Stissing pond, near Pine Plains, Dutchess co.

At several points along the shore a fringe of bushes, about 50 yards wide, is growing, and outside of this a growth of cat-tails and rushes forms what at first might seem to be a cat-tail swamp with a slimy sediment over the bottom. A closer examination shows that under the bushes the surface of the marsh is covered with a growth of sphagnum moss and grass, which extends beyond the limits of the shrubbery and forms an intermediate stage between the cat-tails and the shrubs. Clinging to the cat-tails which lie beyond is another swamp moss, which forms a mat that will sustain the weight of a man. The last 10 feet of the cat-tails growth seems to have no moss, and beyond this are the rushes which are so common in lakes and ponds. The entire area that is covered with moss shows an abundant growth of ferns.

The general level of the growing vegetation is only slightly above the level of the water, though near the shore it is rising somewhat above it. This is undoubtedly due to the fact that the deposit has become a compact mass near the shore, but farther out the water beneath the vegetation permits the gradual subsidence of the mass as the new growth increases the thickness of the deposit. Though the weight of a man will be sustained, the moss sinks about a foot when any one walks on it, which may be taken as a proof that this mass is floating.

Borings about 100 yards from shore showed the growing vegetation and that which was not badly decomposed to be about a foot in depth. Some decomposed vegetation seemed to be clinging to the bottom of the mass, which is apparently floating, as the auger met no resistance for a space of a foot or two and then entered a slimy peat which extended to a depth of about 10 feet. The peat is somewhat gray from an admixture of marl, and at a depth of 10 feet a gray marl is encountered, the bottom of which was not reached.

Below Stissing and Thompson's ponds is an extensive flat which is probably the 500 acre plot referred to by Dr Mather. This extends to Attlebury and is underlain at points by peat. No great deposits were found (1902), though one small bog covering about an acre showed peat to the depth of 11 feet, with an underlying bed of dark blue clay.

The greater part of this flat is covered with a black soil, from 6 inches to a foot in depth, which is underlain by sand or clay.

Halcyon pond, formerly known as Buttermilk pond, has several marshy tracts along its shores, and a white streak of marl can be seen near the center of the pond.

Deuel swamp. About 3 miles west of Amenia, Dutchess co., on the farm of A. W. Smith, is the Deuel swamp, which is the one mentioned by Professor Cassell as belonging to Lawrence A. Smith. About a foot and a half or two feet of black soil

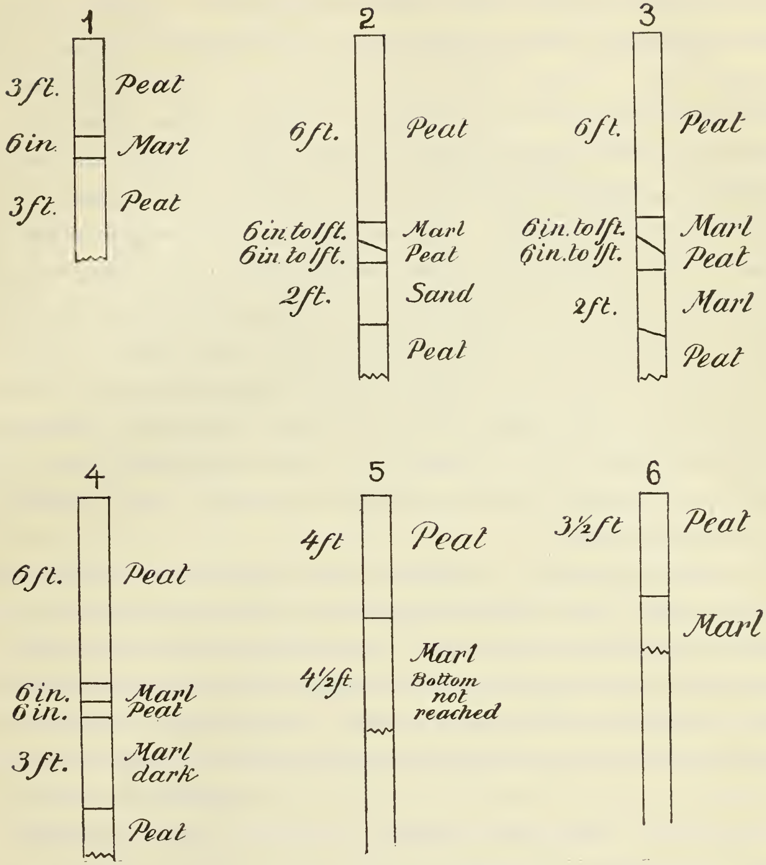
represents the deposit of about 6 feet mentioned in the old report. The swamp is used as a pasture and is covered by heath plants, grasses and some moss, though the amount of the last is small.

The pond just west of Amenia village shows several swampy areas, but they are small and have not reached the stage where bushes begin to grow.

Cicero swamp. The Cicero swamp, one of the best large deposits of peat in the State, is very easily studied. This swamp is about a mile and a half south of Oneida lake, and at its broadest part is about 2 miles wide, while its extreme length is about 25 miles. Three streams, the Canaseraga and Chittenango creeks, flowing into Oneida lake, and Mud creek flowing into Oswego river, pass through different parts of the swamp. The eastern part, sometimes known as the Cowaselon swamp, has been drained by the Douglas ditch, and the reclaimed land has been cleared and put into a high state of cultivation, but the soil is so light that rows of cedars and poplars must be planted as a wind-break to keep it from blowing away.

In the uncleared portions the original vegetation continues to flourish, and the dense forests of soft maple, elm and shrubbery still stand, growing on an accumulation of leaves and tree trunks which is rapidly being converted into peat. Though no sphagnum moss is to be seen in this portion of the swamp, hypnum and other mosses are abundant, and the growth of ferns, particularly the New York fern, is luxuriant.

Sections in various places show the top stratum of peat to be fairly uniform in depth; but the underlying strata are variable in thickness, as will be seen by a comparison of the following sections:



Sections of Cicero swamp at points between Oniontown and Ognon. Sections about 1 mile apart.

These sections were made in nearly a straight line from what is known locally as Oniontown, about 2 miles north of Canastota, through a place designated on the maps of the United States Geological Survey as Oniontown, but known locally as Ognon, to the road from Chittenango to Lakeport. In this article the local names are adopted. The sections were made at points a little more than a mile apart and represent a total distance of about 6 miles. The top stratum was found in all cases to be composed of spongy peat and a large percentage of partially decomposed

wood which, in most cases, may be easily cut by a spade, though near the surface the decomposition is not sufficiently advanced to permit this. In the cultivated portions the surface is a black soil well adapted for all kinds of garden crops. The peaty character of the bog is not shown till a depth of a foot or two is reached, but thence downward to the marl or clay the peat is of apparently good quality. The top layer of peat ranges in depth from 3½ to 6 feet or more and is underlain in most of the swamp by a bed of marl. Two exceptions to this general rule were found north of Oniontown. In the first case clay was found at a depth of 3 feet near a creek in Oniontown, and in the second case, north of Oniontown, in a newly cleared portion of the swamp that has not been burned over to remove the leaves and other loose stuff not as yet changed to peat, the bottom of the peat was not reached at a depth of 6 feet.

The different strata of marl and peat are well shown along the Douglas ditch, and the thinning out of certain layers was well illustrated in one or two cases. As has been stated above, underneath the top stratum of peat is a layer of marl, the thickness of which varies from 6 inches to a foot. Immediately beneath this is another bed of peat which for several miles has about the same thickness as the marl above, but at the eastern part of the swamp the thickness of this bed increases, while near Ognon it gradually thins out and finally disappears. In the marl bed below the second peat deposit a gradual change in the mineral constituents is to be noted, as within the space of a half mile a total change from sand to marl was observed, though the thickness of the deposit continues about the same, and no change in color was to be observed. Whether the peat that underlies these deposits from the western part of the swamp to a point about a half a mile from Ognon, is to be found at Ognon is a question that is yet to be settled. It has been stated that the marl at this point is more than 50 feet deep, but thin beds of peat might easily be overlooked in such drilling as has been done here.

The presence of wood was noted only in the top layer of peat, but this of course does not prove that no wood is present in the lower layers.

In the western portion of the swamp, particularly that part in the town of Cicero, the surface conditions are entirely different from those of the drained portion north of Canastota. The thick growth of arbor vitae, tamarack, scrub pine and other shrubbery makes a typical "cedar swamp," which is almost impenetrable, and the network of roots and fallen branches makes excavation difficult. Near the southern edge, however, the swamp is covered with a forest of deciduous trees. Little, if any, moss is to be seen here, but all through the part where the cedars grow, is a luxuriant growth of sphagnum with some ferns and a liberal scattering of pitcher plants. Here as elsewhere the swamp has a springy, spongy feeling when one walks on it, but there is little if any danger from sink holes after reaching the mossy portion of the bog, though around the margin, where cattle have trampled the vegetation, the soil is a black, slimy mud which is almost impassable. The peat in this portion of the swamp is said to be from 6 to 8 feet in thickness and is underlain by marl. In many places the moss has been stripped by nurserymen for use in packing trees and shrubbery.

Pleasant lake. A small unnamed swamp in the town of Schroeppel, Oswego county, about a half mile northwest of Pleasant lake is a typical example of lake filling. In the center of the marsh is a small pond, the remnant of a fair-sized lake, which is entirely surrounded with an accumulation of peat of unknown depth. A great portion of this bog has recently been stripped of its moss, and consequently the new growth of moss does not furnish such a firm foothold in crossing as does the older and thicker growth of several years. The bog is very spongy and is rapidly filling in the pond at the center, which at present is but a few rods across. The mass underlying the new growth is not so much decomposed as might be expected and would possibly furnish a good fiber for paper. The bottom layers are well decomposed and when dried would make excellent fuel.

The color of the growing moss and pitcher plants in this bog was quite remarkable. In the clumps around trees where the moss has not been stripped, the color of the moss was almost uniformly green, and the pitcher plants were green with the well marked purple stripes so common to them, while in the portions that had been stripped the new growth, both of moss and pitcher plants, was almost uniformly a brilliant reddish purple. This at first sight might seem to be due to a difference in the organic acids furnished as fertilizing ingredients, but the existence of both purple and red moss in the same clump and under identical conditions in the swamp near Owl's Head seems to oppose this theory.

Phoenix. About 2 miles east of Phoenix in the same town of Schroeppel is a large marsh which comes down to the bank of the Oneida river and borders it for about a half mile. Two small creeks pass through this marsh, and along their shores was the only place where observation could be made this year (1902). A growth of elms, maples and other deciduous trees seems to cover the entire swamp. Hardly any conifers are to be seen, and the trees range in size from a foot to 2 feet in diameter. On the occasion of the author's visit, the surface was covered with silt and water and was so soft that only in a few places would it bear the weight of a man. Some portions which have been cleared and drained make good farming land, and it is said that peat underlies a large portion of the swamp. At only one place, however, was any indication of its existence seen by the author, and that was where a telephone pole had been set in the marsh, and a few pieces were brought up in digging the hole. No information in regard to the depth of the peat or the thickness of the overburden was to be obtained, but there is no question as to its existence at this point.

Owl's Head. About a half mile south of Owl's Head station, Franklin co., is a large marsh of apparently very recent origin, which may have been formed within the past 50 years. Around its borders is a dense growth of arbor vitae and tamaracks, a typical "cedar swamp," but with very little peat underlying it.

In the central portion of the marsh, however, no living trees are to be seen, but here and there are the bare trunks of cedars amid the luxuriant growth of sphagnum moss and cranberry bushes. The sphagnum is both red and green, but the different species were not determined. The trunks of fallen trees in many places are indicated by streaks of gray lichens, while underneath circular clumps of the same lichens are found glacial boulders. The depth of the bog is a matter of surprise when the large area is considered. In no place is the entire accumulation of moss and peat more than 4 feet deep, and in many places the shallowness of the deposit is evinced by the glacial boulders which show above the surface. A somewhat remarkable circumstance is the apparent avoidance of these boulders by the sphagnum moss, for almost invariably, the boulder is surrounded by a pool of black water in which the sphagnum does not grow as luxuriantly as in the remainder of the swamp. The peat is of apparently good quality and is underlain by a bed of fine sand, which is well cemented, so as to be almost a sandstone, though it breaks up readily in exposed places. The character of this sand is shown in the ditches at the side of the railroad, where a small waterfall has been formed by the wearing away of the uncemented sand beneath the harder layer immediately underlying the peat. The existence of sand underneath bogs seems to be characteristic of the Adirondack and northern New York swamps, as many of the cedar swamps have such material beneath the peat, instead of the clay that is so much more common in the marshy deposits of the central part of the State.

Madrid and Knapp station. About 2 miles west of Madrid, St Lawrence co., on the Ogdensburg & Lake Champlain Railroad, is a bog extending along the railroad for about a mile and a half on each side. On the south side of the railroad it is said to be about a mile wide, while on the north side it extends for several miles. Much of the surface is covered with arbor vitae, and very little if any sphagnum moss is to be found; none was noticed by the author. Parts of the swamp have been cleared, and on the north

side of the railroad the cleared portions become good farming land, but, on the south side, nothing but a coarse marsh grass takes the place of the woods. At a depth of 4 feet the bottom of the peat is not reached, and apparently the quality is good. Decomposed wood is one of the important constituents in this peat, as is the case in most of the peat deposits in New York State.

Near Knapp station, a few miles east of this marsh, is another "cedar swamp," but, though many excavations were made, there was only one case where the material found might be called peat. The depth of the organic matter was not more than 2 feet and consisted of a brown or black muck underlain by sand. In one place a few clumps of sphagnum about 3 feet across were seen, which are probably the remnants of a once luxuriant growth of this plant.

Though the bottom of the peat deposit at Madrid was not reached, it is probable that, like the swamp at Knapp station it is only a shallow deposit, as the country is comparatively level, and the rocks are in many cases well exposed near the streams.

Montezuma marshes. North of Cayuga lake is a great tract of swampy land, which has been covered with water for the greater part of many years, and is known as the Montezuma marshes. The extreme length from the foot of Cayuga lake to Howland island is about 15 miles, and its greatest breadth is about 3 or 4 miles.

In many ways this is one of the most peculiar swamps in the State, for, though it is at the foot of the lake, it is essentially a delta swamp. After the subsidence of Lake Iroquois, when the waters of Cayuga lake covered the entire area now occupied by the marsh, the Clyde and Seneca rivers flowed directly into Cayuga lake. Gradually the sediment brought by these streams made the water shallower, so that the aquatic plants sprang up, and these in turn have in many places been replaced by marsh grasses. The filling process has not depended entirely on these streams for its supplies, for under a great part of the swamp, a thick deposit of shell marl of remarkable purity is

found, and this must have been formed in comparatively pure water.

At present the Clyde river flows through the swamp parallel to the Erie canal into the Seneca river. The greater part of its sediment is deposited near its banks, forming a dike, which retains the water that flows over the swamp at high water. The Seneca river flows into the lake at its foot, after passing through about a mile or two of the swamp, and with scarcely a turn becomes the outlet of the lake and receives the waters of the Clyde river about 5 miles north of the lake. The amount of sediment carried by these rivers is comparatively small, as they receive the greater part of their waters from Canandaigua, Keuka and Seneca lakes.

Near the borders of the swamp are dense forests of maple, elm, etc., but in the main body of the swamp no shrub larger than an elderberry bush is to be seen, while the mass of the vegetation consists of cat-tails, sweet flags and marsh grasses, which are a source of no little revenue to the people in the neighborhood, who cut the cat-tails and flags for use in tight cooperage and rush bottom chairs and sell the marsh grass for packing material.

The entire absence of mosses in those portions of the swamp visited by the author is a matter of surprise and is a distinct characteristic of this swamp. It may be, however, that some of the woods near the margin have a growth of moss.

Near the margin of the swamp and close to the banks of the creeks and rivers flowing through it, the top soil is merely a black muck with a great deal of silt intermixed, but near the site of the Duryea Portland Cement Works, which were destroyed by fire some years ago, peat of apparently good quality is found. The depth of the deposit is about 6 feet, and immediately beneath it is a bed of marl about 14 feet thick, which is underlain by clay.

This peat is nearly black and very fibrous, being composed almost entirely of cat-tails and grasses. With the exception

of the top layer of undecomposed material, very little difference is to be noticed between this material and other well decomposed peat.

At the foot of Cayuga lake, near the shores of the Seneca river, the accumulation of vegetable matter is mixed with a great amount of silt and is only about 18 inches thick. It is underlain with a clear white sand somewhat intermixed with plant stems.

In view of the fact that at high water the entire marsh is flooded, the small amount of sediment and the comparative purity of the peat are a matter of surprise, but it must be remembered that Cayuga lake acts as a great settling basin, so that little sediment reaches the swamp except from the Clyde and Seneca rivers.

The extent of the peat is unknown, but tests and borings for the location of marl deposits indicate that it is to be found over the greater portion of the marsh.

In the midst of the swamp are several islands, composed principally of glacial debris, which are covered for the most part with a fine sand. The villages of Fox Ridge and Savannah are located on two of these.

In a shallow depression on the top of the high ridge of land south of Savannah, is a small "cedar swamp" which contains peat of apparently good quality. The bottom was not reached on account of the lack of proper tools, so that the character of the subsoil is not known, but the probability is that it is a fine grained sand, possibly a molding sand. This swamp is quite firm and does not have, when one walks on it, the springy, spongy feeling that is so marked in the Cicero swamp and many of the other large swamps. Except for the presence of tamaracks and other moisture-loving trees, there is nothing at this point to indicate the presence of peat, and the presence of this deposit seems to be almost inexplicable; for, even in the wet season of the summer of 1902, the surface was apparently dry, and water did not come into the test holes rapidly enough

to interfere with the digging. At a depth of 3½ feet the peat showed an excellent quality for fuel, but no trace of sphagnum moss was to be seen either on the surface or in the partially decomposed peat. The origin of this swamp is undoubtedly the same as that of the swamp in the kettle on the Pinnacles in Rochester and owes its existence entirely to rain water and moisture from the air.

Pinnacle marsh, Rochester. An interesting peat bog[1] is found in a depression or kettle in the Pinnacle hills within the limits of the city of Rochester. Its total area is only about 1 acre, and the surface is covered with a growth of yellow birch and herbaceous plants. The depth of this bog is 25 feet, and the peat is of good quality. Several sticks of wood were found, which could be cut like soft cheese, but, when seen by the writer some seven years after they were dug, they were very hard, though badly cracked. One of these from a depth of 10 feet has been identified as the red maple (*Acer rubrum*).

Three analyses of material from various depths by Mr Edward Hirschfield give the following results.

			Moisture	Ash
A	from	surface	14.47	2.15
B	"	a lower depth	14.23	3.05
C	"	still deeper	14.51	5.08

This would give for organic matter, A 83.38%, B 82.72% and C 80.41%.

Oak Orchard swamp. The Oak Orchard swamp in Genesee and Orleans counties is divided into three distinct sections, which are covered for the greater part with forest growth and are underlain in most portions by peat. The eastern section is by far the largest of the three, and the depth of peat is greater, but the borings did not show the full depth of the peat. In this portion I did not notice mosses, but am inclined to think it is because careful search was not made. About the center of this section is a large, open tract of grass land underlain by peat of the same

[1]Fairchild, H. L. & Barnum, E. G. The Pinnacle Peat Marsh. Rochester Acad. Sci. Proc. March 1900. v. 3.

character as is to be found in the woods. Several islands of glacial origin are located in this swamp, and some of the best gravel for road building is obtained on them.

The section north of Oakfield is covered with a dense growth of white cedar, and the surface is carpeted with sphagnum and Marchantia. The peat is 3 feet deep, though the last foot is intermingled with marl and calcareous tufa. The subsoil is clay.

North of Alabama the deposit can hardly be dignified with the name of peat, for it is drier than in the other portions and has a sandy subsoil, and the peat contains a large percentage of foreign matter. The forest growth is principally made up of white cedar, though many deciduous trees are found. Sphagnum is not common, but is replaced by a moss of the genus Hypnum.

The eastern section of the swamp would probably furnish a good supply of peat for fuel, but the greatest profit will undoubtedly come from its use in agriculture. The other portions will make excellent soil, but will furnish no peat of any account for fuel.

Byron. About 2 miles northeast of the village of Byron is a swamp about 4 miles long and a mile or a mile and a half wide. It is known as a cedar swamp and is covered with a dense growth of arbor vitae and some pine, hemlock and tamaracks. Ferns are abundant and Hypnum, Sphagnum and Marchantia form a dense carpet, beneath which is a deposit of peat and marl.

For about 3 feet the peat is of good quality, but at that point a crust of calcareous tufa is encountered. Beneath this calcareous tufa no good borings could be made, but the greater part of the material to the depth of 9 feet was marl, though the auger did not bring up much, because the water washed off the greater part, and particles of peat became intermixed in withdrawing the auger. At a depth of about 9 feet good peat is again found, and at 11 feet the bottom was not yet reached.

In this swamp there is a decided odor of sulfureted hydrogen at the point where the calcareous tufa is found, which is probably due to a decomposition of gypsum in solution.

Caledonia. About a mile east of the village of Caledonia is a large cedar swamp which contains some peat, though the quantity is not great. The value of this swamp lies in the extensive deposit of marl which is found here and is used in the manufacture of Portland cement by the Iroquois Portland Cement Co. The surface vegetation could not be ascertained on the occasion of the author's visit, on account of snow, but the top layer of vegetable matter is hardly worthy of the name of peat, as it consists of about a foot or a foot and a half of light partially decomposed vegetation. Beneath this layer is a lenticular stratum of marl, which is underlain by a deposit of peat or lignite about a foot thick. The upper marl deposit has a maximum thickness of about 6 feet and thins out to nothing, so that the two layers of vegetable matter come together and form one deposit. The lower stratum of vegetable matter consists of the trunks of trees intermingled with compact peat, and underneath it is another deposit of marl, which is continuous to a depth of 14 feet from the surface of the swamp. The alternations of peat and marl in this case can hardly be explained except on the supposition that the floating bog on the surface of the lake which once covered this space, sank in the manner described in a former chapter.

Several deer antlers have been found at this place, but it is unknown whether they came from the upper or lower bed of vegetable matter, as they were found in the cement factory when the marl was being put into the drier.

PART 6

Bibliography

Alloway, R. M. Utilization of Peat. Jour. Soc. Arts. 19:30.

Ansted, D. T. Circle of the Sciences; article on geology. Lond. and N. Y. 1862 etc.

Bach, A. Peat Fuel. Inst. Civ. Eng. Proc. 1900–1. v. 147.

———. Art. on Peat. Min. Ind. 7:191.

Bailey, A. Peat Floods in the Falklands. Nature, 34:440.

———. History and Uses of Peat. Am. Jour. Sci. 15:250.

———. Manufacture of Peat. Dub. Univ. Mag. 82:384.

Baskerville, C. Am. Chem. Soc. Jour. 21:706.

Bjorling, P. R. Colliery Guardian. 80:1127, 1183, 1294; 81:21.

Blavier. Considerations sur le charbonage de la tourbe, l'histoire de cet art. Ses procédés et son utilité. Jour. des Mines. 1794 or 1795. i (pt 2), 19 et seq.

Brande. On Peat and Its Products. Roy. Soc. Proc. Jan. 31, 1851; also Am. Jour. Sci. Ser. 2. 11:440.

Byrne ——. On Compressed Peat.

Carter, W. E. H. Peat Fuel: its Manufacture and Use. Ontario Bur. Mines. Bul. 5. Toronto 1903.

Chevalier. Sur la carbonisation de la tourbe à Crouy-sur-Ourcq. Annales des Mines. Ser. 2. 1829. v. 223.

Cleaveland, Parker. Elementary Treatise on Mineralogy and Geology. Bost. 1822.

Cole, G. A. J. Bog-slide in Knocknageeha. Nature. 55:254.

Cook, G. H. Geol. N. J. 1868. p. 481.

Dal, Adolf. Utilizing the Peat Fuels of Europe. Eng. Mag. Nov. 1902. 24:2.

Dana, J. D. Manual of Geology.

Dana, S. L. Muck Manual. Lowell. 1842.

Ells, R. W. Peat. Geol. Sur. Can. An. Rep't. 1888–89. p. 85K.

———. Peat Industry of Canada. Ontario Bur. Mines. 2d rep't. 1892. p. 195.

Fairchild, H. L. & Barnum, E. G. The Pinnacle Peat Marsh. Rochester Acad. Sci. Proc. Mar. 1900. v. 3.

Fruh ——. Ueber Torf und Dopplerit. Zurich 1883.

Gowenlock, N. Peat and its Uses. The Cultivator and Country Gentleman. 1875. p. 275.

Hitchcock, C. H. Reports on Geology of Massachusetts. 1835, 1841, and 1856.

———. Geology of New Hampshire.

Hitchcock, E. Geol. Vt. 1861. 1:174.

Holland, John. History and Description of Fossil Fuel. Lond. 1841.

———. Geology of New Hampshire. v. 3.

Hull, E. Geol. Sur. Ireland.

Hunt, T. S. Peat and its Applications. Geol. Sur. Can. Rep't of Progress. 1866.

Jackson, C. T. Report on the Geological and Agricultural Survey of Rhode Island. 1840.

———. Geology and Mineralogy of New Hampshire. 1844.

Johnson, S. W. Essays on Peat, Muck and Commercial Manures. Hartford 1859.

———. Peat and its Uses. N. Y. 1866.

Julien, A. A. On the Geological Action of Humus Acids. Am. Ass'n Adv. Sci. Proc. 1880. 28:311–410.

Kane, Robert. The Industrial Resources of Ireland. Dublin 1844.

Keller, Theo. Die Torfindustrie. Abs. 2, p. g 24. Hartleben, Wien. 1899.

Kinahan, G. H. Peat Bogs. Jour. Sci. 11:294.

Leavitt, T. H. Facts about Peat. Bost. 1867.

Lesquereaux, L. Origin of Coal. Pa. Geol. Sur. An. Rep't. 1885. p. 109; *also* Hayden's survey. 1872 (Sphagnum as a Peat-maker).

Lyell, C. Principles of Geology. 2:502.

MacCulloch, J. Origin and Formation of Peat. Edin. Philos. Jour. 2:40, 201.

Moore, J. S. On the Growth of Turf Bogs of Fibrous Character. Jour. Roy. Geol. Soc. Dub. v. 12.

Müller, G. Die Verbreitung der Deutschen Torfmoore nach statistischen Gesichtspunkten dargestellt. 2 p. G. 1899. p. 277, 314.

Newberry, J. S. Geol. Sur. O. Rep't of Progress, 1869. Columbus 1871.

———. Geol. Sur. O. 2:122-4.

Newton, W. E. Employment of Peat in the Useful Arts. Jour. Soc. Arts. 8:433.

Orton, E. Peat Bed beneath Drift in Ohio. Am. Jour. Sci. 100:54.

Page, W. H. Making Coal of Bog Peat. Iron Age, Aug. 18, 1898. 62:3.

Patin, Charles. Traité des tourbes combustibles. Paris 1663.

M. Pelouze, *pére.* Traité méthodique de la fabrication du coke et du charbon de tourbe. Paris 1842.

Percy, John. Metallurgy: Refractory Materials, and Fuel. Lond. 1875.

Rennie, R. On Peat.

Ries, Heinrich. Peat. U. S. Geol. Sur. Mineral Resources of U. S., 1901. Wash. 1902.

———. Uses of Peat and its Occurrence in New York State. N. Y. State Geol. 21st An. Rep't. Alb. 1900.

Roth, J. Alg. Chem. and Phys. Geol. 2:639.

Rowlee, W. W. Swamps of Oswego County, N. Y. and their Flora. Am. Nat. v. 31.

Schöndeling. On Manufacture of Peat Fuel. Glückauf. 36:793–97. Abstract Jour. Iron and Steel Inst. 1900. 2:487.

Schroder, F. H. Zur Torfbereitungsfrage. Dingler's Polytechnisches Journal. 1860. 156:128–40.

Senft, F. Humus, Marsen, Torf, und Limonit–Bildungen. Leipzig 1862.

Seyfert, A. G. Peat in Canada. Eng. and Min. Jour. Sep. 23, 1899. p. 371.

Shaler, N. S. Fresh-water Morasses of the United States, with description of Dismal Swamp district of Va. and N. C. U. S. Geol. Sur. 10th An. Rep't. pt 1, p. 255–339.

———. On Peat and Swamp Soils. United States Geol. Sur. 12th An. Rep't. p. 311.

———. Preliminary Report on Sea Coast Swamps of the Eastern United States. U. S. Geol. Sur. 6th An. Rep't.

———. Fluviatile Swamps of New England. Am. Jour. Sci. Ser. 3. 33:210–21.

———. Swamps of the United States. Science. 7:232.

———. Origin, Distribution and Commercial Value of Peat Deposits. U. S. Geol. Sur. 16th An. Rep't. pt 4, p. 305–14.

Sherzer, W. H. Mich. Geol. Sur. 7:10, 24, 156, 157, pt 1, Geol. of Monroe County.

Stern, L. Peat Fuel. Am. Architect & Building News. v. 45.

———. Peat in Germany. Cassier's Mag. 10:111.

Taylor, Richard C. Statistics of Coal. Phil. 1848.

Vogel, August. Der Torf, seine Natur und Bedeutung. Braunschweig 1859.

Websky, Justus. Beiträge zur Erkentniss der Zusammensetzung und Bildung des Torfes. Erdmann's Journal für praktische Chemie. 1864. p. 65–96.

Wheeler, W. H. Commercial Uses of Peat. Nature, 63:590.

White. Geol. Ia. 1870. 2:275–88.

Winchell, N. H. Glacial Lakes of Minnesota. Geol. Soc. Am. Bul. 12:109.

Wragge, R. Utilization of Peat. Jour. Soc. Arts. 19:201.

Zirkel. Petrographie. 1894. 3:626.

Peat, Its Use and Value for Fuel. Ont. Bur. Mines. 1st rep't. 1891. p. 175.

Moss Litter and the Special Advantage of Sphagnum. Ont. Bur. Mines. 1896. p. 185–92.

Ont. Bur. Mines. 1900. p. 21.

Mineral Industry. 2:489; 7, 191.

Wis. State Agric. Soc. Trans. 1874–75. p. 75–92; Geol. Wis. 2:240–46.

Utilization of Belgian Peat. Note in Eng. and Min. Jour. Oct. 4, 1899.

Geol. O. 1:221, 509, 571; 2:222; 3:454, 499.

NOTES ON THE GYPSUM INDUSTRY IN NEW YORK

BY

ARTHUR L. PARSONS

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NOTES ON THE GYPSUM INDUSTRY OF NEW YORK

Introduction

In presenting this sketch of the gypsum industry of New York State, the writer desires to say that the greater part of the history, geology and technology is a compilation of information already published.

The description of the New York State mines and mills is based on field work performed by him. At this time, he wishes to thank the producers of gypsum for the facilities for study which were placed at his disposal and the uniform courtesy which has been extended to him. In particular he desires to thank Mr F. M. Severance, who has furnished much historical data in regard to the Fayetteville deposits.

The publications which have been most largely drawn on are Grimsley's *Special Report on Kansas Gypsum,* Knapp's *Chemical Technology*, Wagner's *Chemical Technology* and New York State Museum bulletin 11.

Gypsum. Gypsum, the hydrous sulfate of lime, has the chemical formula $CaSO_4 + 2H_2O$ and, when pure, contains 32.5% of lime (CaO) 46.6% of sulfur trioxid (SO_3) and 20.9% of water (H_2O). It occurs both in isolated crystals and in large masses of apparently amorphous rock, though even the most compact varieties show cleavage planes and crystal faces under the microscope. It is one of the softest minerals, and is easily scratched with the thumb nail or cut with a knife. In the Mohs scale of hardness it is given as 2, graphite being 1 and diamond 10.

Gypsum crystallizes in the monoclinic system, the crystals being usually tabular or prismatic with pyramidal terminations. Twin crystals are very common. It has a perfect cleavage and from the moonlike luster of the cleavage surfaces is derived the name selenite (Greek σελήνη) which is applied to the clear crystals and platelike cleavages.

When heated moderately in a closed tube, the water of crystallization is given off and the fragments of plaster, when water is added, have the power of recombining with the water in such a way as to form the original compound. If heated to a temperature of 343°C., however, gypsum is converted into anhydrite ($CaSO_4$) which will not harden or set with water.

The principal varieties of gypsum are,

1 Selenite, in transparent plates or crystals

2 Fibrous gypsum or satin spar

3 Alabaster, a compact white gypsum used extensively for ornaments

4 Rock gypsum, a dull variety containing more or less impurities

5 Earthy gypsum, or plaster earth.

When pulverized, all these forms become a white or gray powder. Its specific gravity varies from 2.314 to 2.328. It is sparingly soluble in water, as shown by the following table by Marignac.[1]

Temperature	One part of gypsum dissolves in
0°C	415 parts of water
18°C	386 "
24°C	378 "
32°C	371 "
38°C	368 "
41°C	370 "
53°C	375 "
72°C	391 "
86°C	417 "
100°C	452 "

It occurs very abundantly both in a solid state and in solution. As plaster rock, it occurs in large masses and is usually found

[1] Annales de Chimie, Paris. Ser. 5. 1:274–81. Quoted by Grimsley, Special Report on Kansas Gypsum.

associated with salt, clay and shale. In the manufacture of salt, a certain percentage of gypsum is always present in the brine and must be removed. Sometimes the crystals of selenite obtained from the brines rival in perfection the best that are found in nature.

It is present as a constituent of all sea water in quantities which vary in accordance with the quantities of the other mineral constituents. The following analyses show the constituents of sea water from different seas.[1]

	Caspian sea	Black sea	Baltic sea	North sea	Mediterranean sea	Atlantic ocean	Dead sea
Salts in solution..........	.63	1.77	1.77	3.31	3.37	3.63	22.3
Water....................	99.37	98.23	98.23	96.69	96.63	96.37	77.7
The solid matter contains:							
NaCl.................	58.25	79.39	84.7	78.04	77.03	77.07	36.55
KCl	1.27	1.07	......	2.09	2.48	3.89	4.57
$Ca\,Cl_2$..................	....	......	......	.2	....	....	11.38
$MgCl_2$................	10	7.38	9.73	8.81	8.76	7.86	45.2
NaBr & MgBr........	....	.03	......	.28	.49	1.3	.85
$CaSO_4$................	7.78	.6	.13	3.82	2.76	4.63	.45
$MgSO_4$...............	19.68	8.32	4.96	6.58	8.34	5.29	
$CaCO_3$ & $MgCO_3$	3.02	3.21	.48	.18	.1		
Nitrogenous and bituminous matter .:.........	....	......	......	......	....	....	1

Several theories have been advanced to explain the formation of gypsum deposits, the principal of which are (1) Credner's theory of deposition from sea water, (2) deposition from thermal springs, (3) formation by volcanic agencies, (4) formation by the action of sulfids on limestone, (5) solution and deposition by spring waters, resulting in secondary deposits.

The following statement of H. Credner's[2] theory of the formation of salt and gypsum beds is in the main from a translation by Dr F. J. H. Merrill, appearing in bulletin 11, New York State Museum, entitled *Salt and Gypsum Industries of New York.*

[1] Wagner. Chemische Technologie. 11th Auflage, p. 227. Quoted by Merrill. N. Y. State Mus. Bul. 11, p. 8.

[2] Elemente der Geologie. 6th Aufl. Leipzig 1887. p. 317–20.

(1) *Credner's theory.* The beds of rock salt and gypsum which occur in the earth's crust have been produced by direct separation from sea water or from the water of inland seas in which chlorid of sodium was the principal substance held in solution. In quiet bodies of salt water, the stronger brine formed at the surface by evaporation sinks to the bottom and accumulates there, so that a concentration of the salt takes place from the surface toward the bottom. In open seas full of currents, such a concentration can not occur, for, on the one hand, in consequence of the currents, there is a constant mingling of the stronger and weaker solutions of salt, and, on the other, the rivers replace the evaporated water, but in inland seas, specially those into which but little river water flows, the saturated solution of salt sinks to the bottom, from which rock salt crystallizes out and by continual accumulation, a layer of salt is formed. In periods of excessive rainfall, when the tributary streams are muddy, beds of saliferous clay are deposited, while, on the other hand, in periods of drouth, when no mud is borne by the streams and more water is evaporated than is contributed by the streams, deposits of pure rock salt are formed. If the water of a bay in which such process of evaporation and deposition is going on, contains sulfate of lime, a deposit of gypsum is formed before the separation of the salt begins, because the water becomes saturated with gypsum sooner than with salt. In consequence, beds of rock salt are frequently found overlying beds of gypsum and anhydrite. With a new influx of sea water, the water of the bay becomes less saturated with the saline materials, and the deposition is interrupted, and, in case this interruption occurs before the salt has been deposited, we may have a layer of gypsum overlain by layers of saliferous clay, or in some cases, limestone.

By the drying up of an inland sea originally containing salts in solution, the first substance to separate from the water would be gypsum, then layers of rock salt containing some impurities, after which pure rock salt would be deposited, and on top would be found a layer of the more easily soluble sulfates and chlorids.

In such a case, however, the deposit would be of a comparatively small thickness, since it would contain only the materials which were dissolved in the waters of the inland seas. The great deposits of gypsum and rock salt have undoubtedly been formed in some bay where there has been a continuous or intermittent influx of water containing gypsum and salt. An instructive example of such a deposit and chemically the most complete one in the world, is that of Stassfurt, Germany.

Its lower principal mass consists of rock salt, which is divided by thin parallel layers of anhydrite into beds from 2 to 5 inches in thickness. Upon it rests a stratum, 200 feet thick, of impure rock salt mingled with easily soluble compounds such as chlorid of magnesium, which is divided by thin layers of polyhalite.[1] Upon this is a stratum 180 feet thick, in which rock salt and sulfates, principally kieserite[2] (sulfate of magnesia), occur in alternate layers, some of which are a foot thick. The uppermost bed, about 135 feet thick, is composed of a succession of reddish layers of rock salt and salts of magnesium and potassium (kainite,[3] kieserite, carnallite[4] and tachhydrite[5]) in addition to which are also masses of snow-white boracite.[6] The boundaries between these four principal divisions are not exact, and the change from one to the other is gradual.

(2) *Thermal springs.* In regions where geysers and thermal springs are abundant, in some cases the water contains sulfurous acid, which becoming oxidized, changes to sulfuric acid, and this acting on the carbonates, changes them to sulfates. In this way dolomite may be changed so as to form gypsum and epsomite.

(3) *Volcanic agencies.* Near some of the volcanos, particularly at Girgenti, in Sicily, gypsum, aragonite, sulfur and celes-

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[1] Polyhalite, $2\ Ca\ SO_4,\ Mg\ SO_4,\ K_2\ SO_4 + 2\ H_2\ O$.

[2] Kieserite, $Mg\ SO_4 + H_2\ O$.

[3] Kainite, $Mg\ SO_4,\ K\ Cl + 3\ H_2\ O$.

[4] Carnallite, $K\ Cl,\ Mg\ Cl_2 + 6\ H_2\ O$.

[5] Tachhydrite, $Ca\ Cl_2,\ 2\ Mg\ Cl_2 + 12\ H_2\ O$.

[6] Boracite, $2\ Mg_3\ B_8\ O_{15},\ Mg\ Cl_2$.

tite are found intimately associated with one another. Whether these minerals are formed directly by volcanic action or are secondary minerals, can not in all cases be definitely stated. It is however observed in many specimens that the aragonite and sulfur crystals are inclosed in clear plates of selenite. This fact goes to show that gypsum was formed later than the other minerals, and its formation was possibly due to the action of sulfuric acid, either as a volcanic gas or in solution, as is the case in thermal springs, on crystals of calcite or beds of limestone, though the probability is that the selenite was deposited from water containing gypsum in solution.

(4) *Formation through the action of pyrite on limestone.* The sulfid of iron in the form of pyrite and marcasite is found in many clays, and, when oxidized, forms iron sulfate, which, when brought in contact with the carbonate of lime, brings about a double decomposition, changing the sulfate of iron into siderite (or iron protocarbonate) and the carbonate of lime into sulfate of lime (or gypsum).

(5) *Solution and deposition by spring waters.* In regions where beds of rock gypsum occur within range of ground water circulation, the solvent action of the latter may lead to the formation of secondary deposits at the surface. This theory of origin has been advanced particularly by G. P. Grimsley to account for the earthy gypsum or gypsite that occurs in central Kansas. The secondary gypsum is a soft, incoherent, granular mass, found in low, swampy ground in the vicinity of bedded deposits. On microscopic examination the grains are found to consist of angular crystals that have apparently been formed in place. The secondary deposits of Kansas have much economic importance. The seams or veins which traverse beds of gypsum are also usually of secondary origin.

In the author's opinion, the theory of deposition from sea water is the only tenable explanation of the formation of large, interbedded deposits of gypsum. The reasons for this supposition are as follows: (1) Most of the great deposits are found interstrati-

fied with sedimentary rocks which show little evidence of metamorphism. (2) In no case, so far as has come to the knowledge of the author, has a fossil been found in gypsum deposits. In case the gypsum beds were the result of metamorphism or chemical change from beds of limestone, some trace would undoubtedly be found of the fossils occurring in the original beds of limestone. Even in cases of the most violent metamorphism of limestone, occasional fossils are found, so that the absence of these fossils in the beds of gypsum and the crystalline nature of all deposits, make it almost certain that these deposits were formed by crystallization from solution.

Geography and topography. The gypsum mines of the State are found near the southern border of the area of Salina rocks which may be called the Salina depression. It extends from Lake Erie and the Niagara river into Oneida county. The limits of this depression are marked on the north by the outcrop of the Niagara limestone, which forms a low ridge, known as the Niagara "escarpment."

The southern boundary is marked by the outcrops of the Onondaga limestone, though much of the drainage of the region covered by Devonian rocks passes through the depression. The extreme width of the depression is not more than 20 miles but the length is about 200.

Proof of the existence of this depression is to be found in an inspection of the map, where it will be noticed that there is an almost continuous line of creeks and rivers flowing in an east or west direction between the Niagara river and Utica. At only four points do these streams break through the Niagara escarpment, these four exceptions being the Oak Orchard creek, the Genesee river, Irondequoit river and the Oswego river. Taking the streams which drain this depression in their order from the east to the west, we find the Oswego river, which takes the drainage from Oneida lake and also from the Finger lakes; tributary to the Oswego river, the Clyde and Seneca rivers and Canandaigua outlet; west of the Finger Lake region, Honeoye creek, flowing west

into the Genesee river, and then from a point near Leroy, Allen's creek, flowing east into the Genesee, while north of this, Black creek drains part of the Oak Orchard swamp and flows into the Genesee river; flowing west from Oakfield, the Oak Orchard creek, which breaks through the Niagara escarpment at Medina, while west of this, the Tonawanda creek completes the line across the State and takes the drainage of this part of the State to the Niagara river.

An examination of the topographic atlas sheets of this part of the State shows that there are many elevations within the Salina depression fully as high as the Niagara escarpment. The fact, however, that the drainage of the country overlying the Salina deposits extends in an east and west direction, and that the tributaries of the main streams flow south from the Niagara ridge and north from the Helderberg and higher deposits, gives unmistakable proof that there is here a valley about 180 miles long extending from the vicinity of Utica to the Niagara river. In some parts, the valley is double; this is to be seen west of the Genesee river, where we have Allen's creek and Black creek about 10 miles apart. In the Finger Lake region, it is also double, as is seen north of Seneca and Cayuga lakes, where the Seneca river and the Clyde river flow parallel to each other. In speaking of this region of the State as a depression, it is not the aim of the author to give the impression that it is a broad valley bounded by two ridges. It is rather a rolling plain with many small hills, few of them exceeding 100 feet in hight above the level of the valley.

Formation. Though there is now a marked depression, in former times the depth of the valley was much greater than at present, and, in order to determine the time and manner of its formation, it becomes necessary to consider the agencies that were active in cutting the valley and filling it again.

The continental ice sheet has been considered the most active agent in determining all slight irregularities in surface configuration; but, for reasons that will be set forth in another

paragraph, it seems best to the writer to attribute the formation of the deep depression to preglacial streams, though the formation of the present slight depression is due to postglacial streams.

In order to prove that the original valley was formed in postglacial time, it would be necessary to show that streams with the power of Niagara had passed through this valley for a much longer time than has elapsed since the formation of the present Niagara gorge began. It also, would be necessary to show from what source the large deposits of gravel, sand and clay which fill this depression were derived and also why some of the lakes in central New York were not filled with these same deposits.

Geologists seem agreed in the supposition that, on the retreat of the Laurentian glacier, this region was covered with a succession of lakes, so that the theory of a great river cutting this valley in postglacial time may be discarded.

In the same way, we may discard the hypothesis that this valley was filled in postglacial time, as the filling material is largely sand and gravel from the Medina formation;[1] and, if it were derived from glacial debris at the south, the Finger lakes would show more traces of filling, and the deposits would be at the source and along the sides of these lakes rather than at their outlets; whereas there are no marked accumulations in these places that can not be explained in other ways.

The supposition that much of the cutting was accomplished by the glacier itself seems hardly tenable, inasmuch as the valley is at right angles to the line of glacial flow.

Before considering the question of preglacial cutting, a few facts must be noted, on which to base a theory that the valley was formed prior to the advance of the Laurentian glacier.

(1) Glaciers, in passing over a ridge like the Niagara escarpment, cut the ridge down nearly to the level of the adjoining strata. (2) The bottom of Lake Ontario is about 250 feet below sea level and is nearly at right angles to the direction of the

[1] Fairchild, H. L. Kame Areas in Western New York South of Irondequoit and Sodus Bays. Jour. of Geol. no. 2, v. 4.

glacial flow, and was probably formed by preglacial streams,[1] and in that case the land must have been several hundred feet higher to permit the cutting of such a valley. (3) The Mohawk river flows for a considerable distance over deposits of clay, sand and gravel several hundred feet thick.[2] (4) At Syracuse borings have shown that the deposits of drift are over 400 feet thick.[3] (5) South of Oneida lake and north of the Finger lakes are deep deposits of marl, which must have been formed since the glacial epoch.

Though soundings have not been made in all parts of the depression, the evidence that we have indicates a deep valley which is apparently tributary to the Mohawk river. For the present, the region west of the Genesee river will be left out of consideration, as the deposits of drift in that part are comparatively shallow, and there is presumptive evidence that the drainage was about the same as at the present time. Between Rochester and Lyons is a section which was not cut very deeply, as it was near the dividing ridge between the Genesee basin and the Finger Lake basin. From Lyons to Rome there is a sandy plain, underlain to a greater or less degree by glacial and lacustrine deposits, and the depth of these deposits indicates that at one time a great river must have been here.

Proof that the cutting of this valley was the work of a stream and not of the glacier is found in a comparison of the effect of the glacier on the other formations exposed to its action. Of these deposits there are three formations that are distinguished by their softness, the Medina shales and sandstones, the Salina shales and the Hamilton shales, and in the Salina is to be found the only narrow valley at right angles to the line of flow of the glacier. The Medina deposits at one time occupied a large portion

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[1] Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. N. Y. State Mus. Bul. 45. 9:47–51.

[2] Grabau, A. W. Geology and Paleontology of Niagara Falls. 9:46.
Carll, J. F. Pa. Geol. Sur. I³:363.

[3] Geddes, George. Geol. Sur. of Onondaga. N. Y. State Agric. Soc. Trans. 19:277–79.

An. Rep't of the Superintendent of the Onondaga Salt Springs for 1884. p. 18.

of the territory now covered by Lake Ontario; and though much of the glacial drift is made up of fragments of Medina sandstone, it is generally conceded that much of the erosion of this formation was accomplished by a preglacial river. The Salina deposits, on the other hand, have a shallow valley at one part and a deep valley near by; and the presumption is that, if the deeper valley was made by glacial action, the shallow valley west of Rochester should be deeper, as it was exposed to glacial action longer than the Finger Lake region. In case the shallow valley was the result of glacial action, it still remains a question why the action should have been greater in the Finger Lake region. An examination of the Hamilton deposits shows no marked valley, and, as this formation was exposed to glacial action and is fully as soft as the others under consideration, it becomes almost certain that the Salina valley was not the result of glacial action.

The changes in level which these strata have undergone render it very difficult to determine with exactitude the direction of the ancient river, as it is supposed that the Finger lakes were formed in preglacial times by streams flowing south. The existence of this deep valley at the outlet of these lakes, however, leads the writer to suggest that at a stage between the time when the rivers flowed toward the south and the glacial epoch, the rivers in the Finger Lake valleys flowed into the Salina depression and thence through the Mohawk river.

While this valley was being formed, this part of the State was considerably higher than at the present time, as is shown by the fact that the bottom of the valley at Syracuse and the deepest part of Lake Ontario are below sea level, and valleys are not cut below the level of the outlet of the streams.

It is probable that the solvent action of water has had much to do with making this depression, and, if the existence of deposits of salt in this section could be proved, this would undoubtedly be a most logical explanation of the formation of certain parts of the depression. The existence of salt, however, in this region, is only a matter of conjecture, but in the region south of this, it is found in almost all cases where wells have been

drilled through the Salina deposits. In a few cases where mines have been sunk through this formation, gypsum has been found interstratified with shale above the salt. In the Livonia shaft, three distinct beds of gypsum were encountered, while two were noted in the Greigsville shaft. In all these mines the combined thickness of the gypsum beds is from 60 feet to 75 feet, and in the Lehigh shaft at Leroy a single bed of gypsum 75 feet thick was passed through before reaching the salt. With the exception of the deposit at Fayetteville and Union Springs, no deposit has been found in the Salina depression to exceed 15 or 20 feet in thickness. It seems probable, therefore, that, when this part of the State was covered with water, the salt beds, if they existed here, were subjected to the action of water, and on their solution, crevices were opened up in the overlying strata, allowing rain water to have more ready access to the gypsum deposits. *That salt did once exist* in this valley, is almost unquestioned, because at many points saline springs are to be found, the most important being near Syracuse. Deep borings near Syracuse have however failed to reach any deposit of salt, but, on going up the valley south of Cardiff (about 15 miles south of the city) on both sides of the valley rock salt has been invariably struck, after passing through the Salina shales and limestones.

That the Salina depression has not yet been finished, and that the action of subterranean waters is still an important factor in extending its bounds, is evinced by the salt springs at Syracuse. These springs occur in a deposit of drift, and the only source from which the salt could be obtained is the beds of rock salt which are found about 15 to 17 miles south of Syracuse. Saline springs are found at many places in this depression, among which may be mentioned Montezuma, Greece, Lenox and Delhi.

The action of water in dissolving the gypsum deposits has been observed by several geologists, though in some cases this has been referred to other causes. The first case of this kind that was brought to the author's attention is to be seen at Indian Falls in the mines of the Standard Plaster Co. At these mines, when the first tunnel was being driven into the deposit, a pocket of clay

was discovered, which seemed likely to cut off further mining operations at that point. Careful inspection, however, showed that both above and below this pocket of clay, were solid beds of gypsum. Further investigation showed that, at several points along the walls of the tunnel, smaller pockets ranging in size from a few inches up to three or four feet in diameter had been encountered. The shape of these pockets was much like an inverted hornet's nest or like a large jug with a small opening at the top, and through the opening the water had found its way to the gypsum, bringing with it clay, which replaced the gypsum as it was dissolved by the water. In all cases the clay is found to follow the same lines of stratification as the gypsum; and at first it was the author's opinion that the clay was residual, being left after calcium sulfate had been dissolved. In view of some of the larger pockets however and the nearness of the gypsum deposits at this point to the surface and the broken character of the overlying rock, it seemed certain that these pockets were caused by dissolving the gypsum deposits and replacing them with clay. Strength is added to this supposition by the fact that the limestone underlying the gypsum at this point is unbroken and has a slight dip to the south. The gypsum beds themselves are unbroken, but pockets are found throughout the deposit. The overlying strata, however, are much distorted and broken; but, in view of the lower strata having been subjected to no distortion, no other explanation is left for the broken character of the strata overlying the gypsum than a solution of the gypsum taking away the support from the overlying strata, which naturally would cause the strata to be broken by their own weight. Similar conditions have been noticed in quarries and mines throughout the State, and one case has been mentioned by Prof. S. G. Williams in the article which is quoted a little later.

The distribution of glacial debris in western New York sheds much light not only on the time of the formation of this valley, but on the manner and time of its filling. In the Finger Lake region there is a moraine at the head of each lake, which apparently corresponds with the one south of Dansville and Warsaw,

but no other pronounced moraine is to be found in this region to correspond with the moraines extending from Lockport to Canandaigua or from Medina to Irondequoit bay. It seems probable therefore that, on the advance of the glacier to the Salina depression, the frontal moraine was dropped into the valley, bringing the level of the valley nearly to the level of the Niagara escarpment and giving a gentle incline, over which the glacier passed.

On the retreat of the glacier, several glacial lakes covered this region; and the general topography of this section is much like that around Oakfield, the entire depression being dotted with kames and drumlins. The absence of a moraine to correspond with the one from Medina to Irondequoit bay is probably due to the more rapid retreat of the ice at the eastern border, which would tend to form a more scattered deposit.

In a former paragraph, the writer made the statement that the drainage from this valley probably flowed into the Mohawk river; and, as the present drainage is toward Lake Ontario, this opinion may appear far-fetched. The reasons for this supposition are (1) that the level of this part of the Salina depression is about 125 feet above Lake Ontario, and, if there were an old channel, it would have been more likely that this would be left open than that a new channel would be formed. (2) The glacial debris is held in place by a ridge of Niagara limestone or the Medina sandstone, and this ridge was much higher in preglacial times. (3) The Rome channel is blocked up by glacial debris. Of these three reasons, the second is the only one that needs explanation and is possibly the most important.

As has been previously stated, the deepest part of the Salina channel is from Lyons to Rome and thence through the Mohawk valley, and to this is due the difference in the altitude of the Niagara escarpment in this section and the section west of Rochester. The tendency of the glacier being to bring the country to a level, it naturally follows that the erosive force would be greater in this section, where a narrow transverse ridge was placed between two deep valleys, than in the region west of

the Genesee river, which had not been cut to a great depth. In this way the Niagara escarpment was cut below the level of the col at Rome, so that, when the St Lawrence channel was free from ice, the drainage from the Finger Lakes flowed over the lowest part of the Niagara cuesta into Lake Ontario instead of through the Mohawk to the Hudson.

Geology. The geologic position of the gypsum beds of New York State has been placed by most geologists in the Onondaga salt group of the Silurian system, or, as it is called, the Salina group.

Vanuxem describes this group as follows:

This important group contains all the gypsum masses of western New York and furnishes all the salt water of the salines of the counties of Onondaga and Cayuga. From the point where the Niagara group terminates at the east, it rests upon the Clinton group; and, as the latter group also comes to its end near the first district, it reposes there upon the Frankfort slate, upon which it continues to near the Hudson river.

It forms a part of the high range on the south side of the Mohawk; appearing at the north end of Otsego county and in Herkimer and Oneida, being its northern outcrop. It makes its first appearance by the side of the Erie canal at the east end of Madison county, and from thence west the canal was excavated in the group.

The Onondaga salt group may be divided into four deposits. There are no well marked lines of division between the deposits; but for practical purposes the divisions are sufficiently obvious.

The first or lowest deposit is the red shale, showing green spots at the upper part of the mass. 2d, The lower gypseous shales, the lower part alternating with the red shale, which ceases with this mass. 3d, The gypseous deposit, which embraces the great masses quarried for plaster, consisting of two ranges, between which are the hopper-shaped cavities, the vermicular limerock of Eaton, and other porous rocks. 4th, and lastly, Those rocks which show groups of needle-form cavities placed side by side, caused by the crystallization of sulfate of magnesia[1], and which may be called the magnesian deposit.

The whole of these deposits are found between Oneida creek and Cayuga lake. To the east of the creek, they do not all occur, as will subsequently be made known. They thin out to the eastward and probably terminate entirely a few miles east of the Hudson river;

[1]Sulfate of lime most probably. [F. J. H. Merrill]

from which point their thickness gradually increases towards the west, and reaches its maximum in the counties of Onondaga and Cayuga, where it is not less than 700 feet. The gypsum has not been seen east of the western part of Oneida county. The red shale comes to its end at the east end of Herkimer county; and the whole group is reduced in the Helderberg in Albany county to a few feet of light gray or lavender-colored, compact calcareous rocks with pyrites, separating the Frankfort portion of the Hudson river group from the Waterlime series.[1]

Prof. James Hall[2] describes the Salina group as follows: Succeeding the Niagara group is an immense development of shales and marls with shaly limestones including veins and beds of gypsum. The general color is ashy approaching drab with some portions of dark bluish green. The lower part is of deep red with spots of green. Succeeding this, where protected from atmospheric influences, the rock is blue like ordinary blue clays, with bands of red or brown. This portion and that succeeding it are often green and spotted, and contain seams of fibrous gypsum and small masses of reddish selenite and compact gypsum. From this it becomes gradually more gray with a thin stratum of clayey limestone, which is sometimes dark, though generally of the same color as the surrounding mass. The formation terminates upward with a gray or drab limestone called by Vanuxem the "Magnesian deposit." The red shale forming the lower division of the group is well developed, but in the third district has not been found west of the Genesee river. It appears in the eastern part of Wayne county, as indicated by the deep red color of the soil which overlies it.

At Lockville a greenish-blue marl with bands of red has been quarried from the bed of the Erie canal. West of the Genesee this is the last of the visible mass. The red shale has either thinned out or lost itself, gradually becoming a bluish green, while otherwise the lithological character remains the same. On first exposure it is compact and brittle, presenting an earthy fracture. But few days are necessary to commence the work of destruction, which goes on until the whole becomes a clayey mass. The prevailing features of the second division of the group are the green and ashy marl with seams of fibrous gypsum and red or transparent selenite often embracing nodules of compact gypsum. The third division comprises all the gypsum beds of the fourth district which are of economic importance. In this third division hopper-shaped cavities occur in Wayne and Monroe counties, but rarely in Genesee or Erie.

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[1] N. Y. State Mus. Bul. 11. 3:22–23.

[2] Geology of the 4th District.

There is scarcely any well defined division between the shales and shaly limestones of the third division and the so called magnesian deposit which overlies it.[1]

An investigation of the rocks near the plaster quarries at Union Springs has led Mr S. G. Williams to refer the gypsum deposits at this point to the Lower Helderberg; and his grounds for this supposition are here quoted in his own words.[2]

It is well known to geologists that the strata containing the gypsum deposits of New York, ranging from Madison county westward, at the time of the State Geological Survey were all assigned to the third of the four groups into which the Salina period was divided; and that these gypsum deposits were described as isolated masses of possibly concretionary character contained in the inclosing beds. The gypsum beds a short distance north of Union Springs, Cayuga co. are much the most extensive of these deposits. A recent examination of the gypsum beds and their inclosing strata, accompanied by some fortunate discoveries of somewhat abundant though often badly preserved fossils, has not only shown that the gypsum in this locality exists in continuous beds with a considerable degree of regularity, but has also afforded reasons for believing that this portion of the gypseous series belongs rather with the Lower Helderberg than with the Salina.

A section at this point eastward, and thus nearly in the line of strike, from the level of Cayuga lake to the top of the Oriskany sandstone, is about 114 feet thick and consists of the following members, numbered upward from the lake level.

No. 8	Oriskany sandstone in a single fossiliferous seam	3 feet 8 inches
7	Drab limestone, upper beds with thin, undulating laminae: exposed	10 "
6	Limestone revealed only in occasional outcrops, leveled with Locke level, about	46 "
5	Thick bedded blue limestone, containing *Meristella laevis, Orthis oblata,* small form, *Rynchonella semiplicata, Strophondonta varistriata,* etc.	10 "
4	Drab limestone, holding a branching fucoid and *Nucleospira ventricosa*	4 "
3	Measures concealed, leveled with Locke level	20 "
2	Thin bedded blue limestone, terminating below with a seam 2 feet thick	4 "
1	Drab limestone unevenly bedded with two or three thin blue seams, to lake level	16 "

[1] N. Y. State Mus. Bul. 11. 3:24–25.
[2] Am. Jour. Sci. Sep. 1885.

The mean of four readings with the aneroid agrees well with the total thickness here given. The beds of no. 1 have yielded fossils at three points, all at about the same level near the middle of the series, viz: one head of *Eurypterus remipes,* and tolerably abundant *Leperditia alta, Nucleospira ventricosa* and *Meristella bisulcata.*

Besides the irregularities in the bedding of no. 1 mentioned in the section, the strata in this region are occasionally affected by local disturbances. The most common of these is a sudden tilting of the beds at a low angle, continuing sometimes a number of rods, which is caused apparently by a failure of support from below. One such disturbance occurs near the middle of no. 1, causing the beds to dip very perceptibly to the southward for a short distance. More considerable disturbances of a like character affect the Corniferous limestones of Union Springs, about 2 miles south of the plaster quarries, two of which have come under my notice. One of these, which was mentioned and figured in the report of the 3d district, and by which the limestone is caused to pitch suddenly south at an angle of 13°, has within the last two years been more fully developed by the opening of a large quarry immediately south of the disturbed beds. In this quarry, which is capped by a considerable thickness of Marcellus shales with a band of concretionary limestone, is revealed a flat-topped anticlinal arch with an E. W. strike, the southern limit of which has not yet been reached in quarrying, while the northward dipping side, with an angle of 20°, is near the junction with the southward dipping beds described by Vanuxem. In one of the most extensive plaster quarries also, there occurs a gentle anticlinal with meridional strike, through which the present working floor of this quarry and the one to the north of it, is made to dip eastward at a small angle as far as the workings extend; and if this dip continues, it will increase by a number of feet the space between nos. 2 and 4, which was found by leveling to be 20 feet. The knowledge of these occasional irregularities demanded caution in assigning the gypseous series, with an average thickness of 25 feet, to its proper place in the section, specially since the space of nearly a quarter of a mile between the fossil-bearing beds of the lake shore and the gypsum quarries, is concealed by drift. Fortunately the valley of a brook, separated only by a single field from the nearest quarry at this point, affords a continuous line of outcrop from the fossiliferous limestone on the lake to the top of no. 2, by which its continuity is assured. The top of no. 2 is 20 feet above the lake level, which is also the hight of the floor of the nearest plaster quarry. Add to this the fact that the character of no. 2 corresponds with that of the bed of tough blue limestone which forms the bottom of

all the southern quarries, and there is no reason to doubt that the plaster series belongs in the covered space between no. 2 and 4, widened probably by the local easterly dip mentioned above, a position to which, in the absence of any local irregularities, it would be unhesitatingly assigned by any geologist.

There is then no doubt that the gypsum deposits here form a part of the fossiliferous series, lying above the beds containing *Eurypterus, Leperditia alta, Nucleospira ventricosa* and *Meristella bisulcata*, and below, or in close connection with beds containing well marked fossils of the Pentamerus and shaly limestone horizons of the Lower Helderberg. It should also be borne in mind that, apart from the gypsum beds, the entire section from the lake level to the Oriskany sandstone, is made up of drab limestones with frequent blue seams, sometimes of considerable thickness, as in no. 5. Some of these limestones, both at the bottom and top of the series, are highly laminated, showing thin layers of slightly different colors, and nearly all hold a considerable amount of impurities.

There is indeed, even if we set aside the fossil evidence now gained as to geological age, no such lithological change in the limestones as to warrant the reference of the lower portion of them to the Salina period, and the upper part to the Lower Helderberg. Nor is it likely that any such reference would ever have been made had it not been for the presence of the gypsum deposits. These deposits in the regions both east and west of Cayuga county appear, from the State reports, to occupy a pretty definite *place in strata bearing intimate relations with the shales* of the salt group; to occur in irregular masses inclosed in marly shales whose lamination they sometimes share and sometimes disturb; and to be divided often into two "ranges" by a peculiar porous or vesicular lime rock, or by shaly limestones, holding indications in hopper-shaped accretions of the action of saline waters. It was natural, therefore, in the absence of any evidence to the contrary, that the occurrence of gypsum in any additional locality not obviously removed from its usual horizon should lead to the reference of both gypsum and the accompanying strata to that horizon. A brief description of the gypseous series here however will show, I think, that its structure bears no very close resemblance to that of the gypsum of the Salina period; that its character is intimately related with that of the accompanying limestones; and that both character and structure tend to indicate for it a different geological horizon, if not a different origin from that of most of the other gypsum deposits.

It may be said at the outset that the gypsum deposits of this region are not irregular masses: they have no relations there-

fore with marly strata surrounding and inclosing them, they are not associated with any "vermicular lime rock" within them, nor with anything answering to the 4th or Magnesian division of the Salina lying above them. In one point only do they bear a superficial resemblance to the deposits elsewhere: they occur in two "ranges," or rather beds, separated from each other, however, not by shaly or vesicular lime rock, but by a bed called *slate* by the quarrymen, made up of thin seams of gypsum, interlaminated with other layers of shale.

The gypseous series here has a very uniform character, consisting as it does of three persistent and tolerably regular members. *First* occurs the lower seam of gypsum highly laminated and separating into several distinct layers, somewhat harder than the upper seam, and of a usual thickness of 7 feet, varying but little in this respect. *Second*, upon this rests a stratum about 3 feet thick called *slate* by the quarrymen, consisting of alternating laminae of gypsum and shaly matter, and said to be gypseous enough in the northernmost quarries (which are now little worked) to be ground for plaster. *Third*, the upper gypsum bed which closes the series, varies much in thickness, from nothing to upwards of 20 feet, averaging possibly 15 feet. Its variability in thickness is probably due mostly to denudation, since it is capped by yellow drift clay in nearly every place where it is laid open by workings. The upper gypsum bed shows little disposition to separate into distinct layers save in the northern quarries, and is softer and somewhat less dense than the 7 foot bed. It was thought to be of better quality until analysis showed it to be nowise superior. All the members of the series show occasionally small spots and thin, scalelike laminae of sulfur, more specially on dirt seams. The upper bed, I am told, contains more of the sulfur than the lower, and the slate seam more than either. The gypsum of both seams varies from a light to a somewhat dark gray.

The gypseous series here shows, therefore, no tendency to form isolated masses, save where denudation may give it that appearance, in which case it is enveloped in drift clay. Two proprietors of long experience, however, inform me that the entire set of beds is occasionally cut across by what are called "mud seams" from 1 to 5 feet wide, that the mud seams are often of a thin laminated structure and sometimes contain a little gypsum and selenite, and that the gypsum beds abut against them regularly on both sides. The only example of this kind of replacement that has come under my notice was in the edge of one of the quarries, where, at the time of my last visit, the lower gypsum bed and the *slate*, the only members there

present, had suddenly given place to black, thin laminated mud, and above to harder, thin bedded ferruginous shale, the mud seams abutting against the gypsum and *slate* in a reentrant fashion. The lamination of the mud appeared to correspond to that of the gypsum against which it abutted, and one block was hard gypsum at one end and black laminated mud at the other, although elsewhere the gypsum and the mud were separated by irregular joint-like cracks. I was inclined to attribute the change to the action of water penetrating to the beds through crevices in the clay cover.

The limestone of that part of the series in question which encloses the gypsum beds is of a prevailing drab or ash color, with a few blue seams, of which no. 2 of the section is the only important one. It is often highly laminated, has a considerable amount of impurities as has already been said, and by reason of the earthy character of these impurities, it shows such a disposition to absorb water as to unfit it for all but the roughest purposes. A fragment of no. 1 gained in weight 3% by two hours' soaking, while a like fragment of the blue limestone no. 2 showed no appreciable gain in the same time.

The character of the limestones just described seems to me to throw light on the question of the origin of the gypsum beds; these I think have obviously been formed from the earthy drab limestone of the horizon at which they appear, as the result of the action upon them of acid waters originating in sulfur springs, which are still somewhat abundant in this region, and which it may be presumed were more abundant at an earlier geological date. The porous character of the drab colored limestones would facilitate such transformation, under favorable circumstances; while the imperviousness of the blue limestone which underlies the series would limit it below. Reasons for this opinion as to the origin may be found: *first,* in the striking similarity in structure between the lower gypsum and the associated drab limestones, both having the same highly laminated character, while both the lower gypsum and the northern part of the upper, are also distinctly bedded; *second,* in the structure of the intermediate bed, containing as it does alternate layers of gypsum and shale, as if whatever was lime in an impure shaly limestone had been transformed to gypsum, leaving the remainder unchanged; *third,* in the presence in all the gypsum beds of native sulfur, which would be difficult to account for on any theory of origin which would not include the action of sulfureted waters; *fourth,* in the composition of the gypsum itself, which is gray, and like the limestones somewhat impure, containing in com-

mercial samples an average of 80½% of lime sulfate with 14% of earthy matter, 5% of lime and magnesian carbonates, and, quite significantly, .6% of lime phosphate and organic matter, these last ingredients suggesting an organic origin, while the residual lime and magnesia point to the probable original condition of the deposit. It may be added in this connection that in the limestone no. 1, in close proximity to one of the fossil localities and nearly at the same level, occurs a small isolated mass of decomposed gypsum, possibly 10 cubic feet in dimensions, which is due apparently to the agency of a small sulfurous percolation now extinct.

I believe, therefore, that the structure of the great gypsum deposits of Cayuga county separates them sharply from those existing elsewhere in New York in the strata of the Salina period; and that their associations with limestones, both below and above them, containing fossils of the lower divisions of the Lower Helderberg, as well as the nearly uniform character of the rock series from the lake level to the Oriskany sandstone, indicate for them a place in the lower portion of the Lower Helderberg in which I include the Waterlime group.[1]

Professor Williams's deductions in regard to the geologic position of the gypsum at Union Springs are apparently well grounded, but it seems that there is some difference of opinion as to where a geologic period begins. Apparently, Mr Williams considers the Lower Helderberg formation as beginning where the first fossils which are typical of these deposits made their appearance. If this ground be accepted, it will be necessary to refer the deposit at Union Springs to the Lower Helderberg. The general opinion of geologists, however, seems to be that the gypsum deposits of the State belong with the Salina group, and Dr J. M. Clarke has recently assigned the Tentaculite limestone to the Salina rather than to the Lower Helderberg, where it has been included for many years. In Luther's section of the Livonia salt shaft, the upper gypsum bed is referred to the Lower Helderberg. The lower and thicker deposits are referred to the Salina period; but, in view of the more recent opinion of Dr Clarke concerning the Tentaculite limestone, it is very likely that the upper gypsum bed at Livonia would also be referred to

[1] Williams, S. G. Geological Relations of the Gypsum Deposits in Cayuga County, N. Y. Am. Jour. Sci. September 1885.

the Salina, and it would undoubtedly have been referred to this formation at the time when the section was published, were it not for the fact that Dr Clarke's idea of the geologic periods seems to have agreed with that set for them by Mr Williams, namely, that the geologic periods begin when the first fossils of that period appear.

The eastern limit of the known gypsum deposits is in Madison county, though rocks of the Salina group are found as far east as Schoharie. From Madison county to Buffalo more or less continuous deposits are to be found throughout the Salina depression. Most of the deposits that have been developed have been found in the hills rising above the level of the surrounding country, and as a usual thing the gypsum deposit does not have a great thickness. At Fayetteville the deposit reaches a thickness of 60 feet, and between Syracuse and Marcellus several thousand tons were taken out in making the railroad cuts on the Auburn division of the New York Central Railroad. The thickness of the latter deposit has not been measured, but from the outcrops that I have seen, I should judge that it is from 40 to 60 feet thick.

When the gypsum deposits of the State were first precipitated, they were undoubtedly continuous, but glacial action and the solvent action of water have taken away a great portion of the gypsum, leaving isolated deposits under a slight covering of rock or earth in a great part of the Salina depression.

The gypsum deposits are pierced by all the salt wells in the State outside of the Salina depression, but no information of value is obtained from a study of the well sections. The salt mines, however, give data that are very important.

In the shaft of the Livonia salt mine,[1] gypsum was found at a depth of 1078 feet in Lower Helderberg rocks. The deposit is 9 feet thick and is a mixture of gypsum and a so called marlite. At the depth of 1138 feet is another bed of gypsum 45 feet in thickness, while at 1278 feet is an 18 foot deposit with a band of

[1] Luther, D. D. Livonia Salt Shaft. N. Y. State Mus. 47th An. Rep't. 1894. p. 215–324; N. Y. State Geol. 13th An. Rep't, p. 25–130.

shale separating it into two parts. The latter deposits are in the Salina formation.

The thickest deposit that is known in this State is in the Lehigh salt shaft at Leroy, where at a depth of 389 feet a deposit 75 feet in thickness was found. The rock is light colored in some parts, and samples that have been seen by the author compare well with the rock found at Oakfield and Garbuttsville. A project is on foot to make use of this deposit in the manufacture of stucco.

In the shaft of the Retsof mine at Retsof N. Y., a bed of gypsum 47 feet thick was found at a depth of 613 feet. This deposit is considered the top of the Salina in both the Retsof and Lehigh mines, though in the Livonia shaft it is supposed that the limestone and hard shale just above the 45 foot bed are Salina.[1]

It will be seen from these sections that the thickness of the deposit increases as we go south of the Salina depression, and from the appearance of this thick bed at practically the same horizon in these three mines, it seems reasonable to expect to find it throughout the greater part of western New York.

The future developments in gypsum mining in this State will probably be made south of the region from which the supply is now obtained.

HISTORY

The use of gypsum as a cementing material has been known for at least 4000 years, as shown by an analysis of the mortar used in the construction of the pyramid of Cheops, and that this use was known among the ancient Greeks is shown by the writings of Theophrastus and others. The precise date when this material was first used in this way is not known. Theophrastus records that plaster casts were first made by Lysistratus, but little use was made of the discovery, and the art was lost. This use was revived by Verocchio about 1450 A. D. and was of service in

[1] Luther, D. D. Report on the Geology of the Livonia Salt Shaft; N. Y. State Geol. 13th An. Rep't 1894. p. 25–130. Also N. Y. State Mus. 47th An. Rep't, p. 215–324.

making copies of ancient sculpture which were discovered about that time.

The use of compact gypsum or alabaster was quite common in ancient times, and frequent references are made to it in ancient books. It was chiefly employed in the manufacture of urns, vases and other ornaments. Slabs of alabaster were sometimes used for windows, and the Romans used plates of the transparent gypsum or selenite for this purpose.

The industrial development of the last 20 years has been marked by a most wonderful increase in the use of gypsum. Up to that time the demand for raw gypsum in the United States was almost as great as that for plaster of paris, and the use of the latter article was very limited. With the discovery of processes by which the set of stucco may be retarded and the hardness of the finished product increased, plaster of paris has replaced lime mortar to a great extent as a wall plaster. Another factor in the increased production of this material is found in its use in Portland cement to retard setting.

In the year 1885 Prof. Carl Straub, then of Syracuse N. Y., patented a fluid composition for retarding the set of plaster of paris and at the same time hardening the material. Early in the next year (1886) he obtained another patent for a dry compound to be used in the same way. This was the starting point of the hard wall plaster industry in this country. Professor Straub associated with himself Mr S. S. Ruston, and under the firm name of Straub & Co. the first business of manufacturing hard wall plaster was established at Syracuse. The new material met with favor from the start, and in January 1887 the Adamant Manufacturing Co. was organized with a greater capital and took over the plant and business of Straub & Co.

At the outset only Nova Scotia and European gypsum were used, as at that time one of the things much desired was to have a white, smooth surface to the wall. The demand, however, for a wall plaster having the advantages of plaster of paris in the matter of quick setting and freedom from shrinkage, so that a building could be more quickly occupied than when a lime plaster

is used, caused manufacturers to experiment with the gypsum of New York and other states with a view to utilizing it for this purpose. It was found that in all places where absolutely white finish is not required the New York gypsum was fully equal to the imported in strength and setting qualities. As a consequence, mills were erected, and the manufacture of plaster of paris and wall plaster from New York gypsum was begun on a large scale. The erection of buildings for the World's Fair at Chicago and other expositions which have taken place in the last 10 years has probably had a greater effect on the gypsum industry than any other development. The thousands of tons used in the manufacture of "staff" would of themselves make quite a difference in the industry, but the greater effect probably came indirectly through the thousands of people who for the first time realized the strength and durability of this building material.

The sources from which the world's supply of gypsum is obtained are to be found in nearly every portion of the globe. The most important deposits in foreign countries are those at Montmartre, near Paris, and those of Nova Scotia. It is also found in various parts of Germany, in Norway, Austria, Bohemia, Italy, Egypt, Arabia, India and Persia. In the western hemisphere it occurs in nearly every great division. Fine deposits occur in Chili and other South American republics, while in the north it is to be found in the provinces of Ontario, Quebec, New Brunswick and Nova Scotia. Its occurrence in the United States is widespread, and there is scarcely a state in which it may not be found. From a commercial point of view the entire supply comes from the following states and territories, New York, Ohio, Michigan, Iowa, South Dakota, Kansas, Oklahoma, Wyoming, Colorado, California, Indian Territory, Arizona, Montana, Oregon, New Mexico, Texas, Utah and Virginia.

With the increased demand for this material, deposits which were formerly considered inferior have been opened up, new deposits have been discovered, and the product of this country finds a ready sale in competition with the best Nova Scotia gypsum.

In this State the development of the gypsum deposits followed close on the settlement of the country, but the date when gypsum was first mined is not known. The deposits at Fayetteville were opened in 1812; and in 1822 Cleaveland stated that "In the western part of New York, sulfate of lime is very abundant, particularly in Onondaga and Madison counties, and in the vicinity of Cayuga lake, whence several thousand tons are annually exported to Pennsylvania." Though statistics of production are not available for the greater part at this time, there is little reason to think that there were any marked fluctuations in the product other than those caused by differences in climatic conditions and a natural growth. Since 1889 it has been observed that there is little variation in the quantity of land plaster used from year to year, and this was practically the only form in which gypsum from this State was marketed prior to 1890.

USES

The purposes for which gypsum has been used since it was first discovered are numerous and varied. In its natural state it was used as a building stone at a very early date, on account of the ease with which it could be dressed. Examples of its use in this way were the temple of Fortuna in Seia and the buildings of Arsoffa Emii in Arabia.

The transparent plates of selenite were used by the Romans in place of glass for windows, and translucent slabs of alabaster were used at a later date in some buildings for the same purpose.

Alabaster and satin spar were used at an early date in making ornamental vases and similar ornaments, and at the present day they are still cut for this purpose in Germany and Russia. When cut *en cabochon,* satin spar has the chatoyancy of cat's-eye, but can not be used as a gem on account of its extreme softness. When ground to a powder, it is used without calcining as a fertilizer, as an absorbent and deodorizer, as an adulterant and in the manufacture of glass and porcelain.

As a fertilizer, gypsum has long been used in the powdered condition under the name of land plaster. Its use in this country

was, it is stated, largely the result of the efforts of Benjamin Franklin, who is reported to have sown plaster on a clover field near one of the principal roads in Pennsylvania in large letters so as to form the sentence, "This has been plastered with gypsum." The clover which had been plastered was greener and more thrifty than that which had not received an application of the plaster, and the letters were distinctly visible at some distance.

Probably the action of no fertilizer is so little understood as is that of gypsum; and those who have used it are in some cases enthusiastic in its favor, while others are just as pronounced in their opposition to its use. It is a question whether it has any direct fertilizing value, though the ashes of nearly all the plants contain varying percentages of lime and sulfuric acid which were possibly derived from gypsum. Its value as a fertilizer is attributed by Liebig to its power of fixing ammonia from the atmosphere so as to make it available as plant food.

It is the opinion of De Candolle that gypsum is a stimulant to the leaves of plants; while Chaptel considered the stimulating effect to be due to the saline character given to the sap of the plants.

Sir Humphrey Davy regarded gypsum as a direct source of plant food, because a certain percentage of sulfate of lime is found in the ash of plants; but the most satisfactory explanation of its action is the theory advanced by Storer, which supposes a threefold action, the first mechanical and the others chemical.[1]

1 The salts of lime have a tendency to flocculate loose soils, making the soil more granular, while an opposite effect is observed on clay soils where the soil is broken up into finer portions. Gypsum as a salt of lime acts to a slight extent in this way, but other lime compounds act much more rapidly.

2 It is supposed that gypsum gives up part of its oxygen to certain organic substances in the soil, thus preparing them for plant food.

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[1] Storer. Chemistry of Agriculture. 1887. 1:206–16. Quoted by Grimsley, Gypsum Deposits of Kansas, p. 132.

3 Gypsum decomposes the double silicates of the earth, setting free potash as a double sulfate. This action according to Storer is as follows:

$$\left.\begin{matrix}Al_2O_3\\ CaO\\ K_2O\\ H_2O\end{matrix}\right\} x\ SiO_2+CaOSO_3=\left.\begin{matrix}Al_2O_3\\ CaO\\ CaO\\ H_2O\end{matrix}\right\} x\ SiO_2+K_2O\ SO_3$$

In this way potash is furnished in solution to the roots of the plants, but a similar result should follow the application of quicklime, with the difference that potash would be set free as K_2O, which would unite with carbon dioxid, which is present in all natural water, forming the carbonate, instead of sulfate.

In considering the mechanical effect of lime salts on the soil, it is to be noticed that the action on sandy or gravelly soils is entirely distinct from the action on tough clay soils, but in each case the soil is made more granular.

The lime undoubtedly has no material effect in either case till it is in solution, and it seems probable that the effect on the clay soil is due almost entirely to the chemical action of the salts of lime on the potash occurring in the clay. The action of lime on loose sandy soils has been illustrated by placing lime in a muddy liquid, whereby the mud flocculates and falls to the bottom. This, however, does not seem to be a satisfactory explanation of the action of the lime on the soil, inasmuch as, when such flocculation takes place as is seen when lime is put into muddy water, it is largely due to the fact that alum compounds have a tendency to precipitate both solid and dissolved materials in any liquid in which they may be found. This reaction is probably due to the chemical change noted above, by which the lime is rendered insoluble and the potash set free. In this case the particles of the new compound of lime are likely to be more compact than the clay or the solution of lime, so that they more readily fall to the bottom. The flocculation observed in sandy soils is due largely to the action of the lime on the clay which is almost invariably found in these soils.

The effect of lime in gravel beds may be noticed when such a deposit is uncovered; for even in dry seasons the pebbles are found in many cases to be covered with a slimy material which on exposure to the air, becomes solid. This in most cases is a salt of lime, usually the bicarbonate, though the sulfate would have much the same effect. A coating of such slimy material has an important chemical action on the pebbles with which it is found, if these be slate, shale or flagstone; for in this case, the lime acts on the potash in these rocks in the same way that it would on the potash in clay. In some soils particles of glauconite or green sand are present, and, as this substance contains an appreciable amount of potash, which in its natural state is only slightly available as plant food, the salts of lime would have an important effect in setting free this potash.

The amount of moisture retained by a sandy soil where lime salts are not present is nearly if not quite as great as where they are absent, so that the theory that gypsum absorbs moisture and stores it for plant food may be discarded, and the treatment of its action on the constituents of the soil may be taken up under the third heading. As a matter of fact, gypsum does not take up water; but as has been stated before, water dissolves gypsum, and, when the water evaporates, the gypsum separates in its former condition.

The theory noted above, that gypsum gives up part of its oxygen to organic substances to promote decomposition, seems to be without foundation, as the experiments of Sir Humphrey Davy show that not the slightest difference in the time of putrefaction can be noted between meat treated with gypsum and that not so treated. That gypsum does absorb ammonia or change it to the sulfate is an unquestioned fact, and it may well be employed about stables as an absorbent of this valuable fertilizer; but that it promotes the formation of ammonia seems to be disproved by Davy's experiments.

The chemical action of gypsum and other salts of lime in setting potash free from insoluble compounds is undoubtedly the only tenable explanation of the wonderful results following their

use; and the material so acted on is usually clay, which is essentially a hydrated silicate of aluminum with certain percentages of potash and soda, and is derived from the decomposition of the feldspar of granite rocks. Shale and slate are modified forms of this material and are acted on in the same way as the clay in its plastic form.

In the greensand region of New Jersey I talked with a farmer, who said that he had for many years used greensand, but that, as time went on, he failed to get a proportionate increase in the crops from the application of this material. He gave a light coating of lime to a meadow, and on that portion where the lime was applied, the crop was nearly twice as heavy as on the portion not so treated. Inasmuch as greensand marl contains about 3% of potash, the explanation seems to be that the lime set the potash free, with a marked increase in the crop.

Boussingault discovered that an increased percentage of potash in the ashes of clover was apparently the result of the application of gypsum to the soil. His experiments carried on for two years on the same land gave the following results.[1]

	1841		1842	
	Land with gypsum	No gypsum	Land with gypsum	No gypsum
Ashes free from CO_2	270	113	280	97
Silica	28.1	22.7	10.4	12.7
Oxids (iron manganese and alumina)	2.7	1.4	(?)	.6
Lime	79.4	32.2	102.8	32.2
Magnesia	18.1	8.6	28.5	7.1
Potash	95.6	26.7	97.2	28.6
Soda	2.4	1.4	.8	2.8
Sulfuric acid	9.2	4.4	9	3
Phosphoric acid	24.2	11	22.9	7
Chlorin	10.3	4.6	8.4	3

From the foregoing it will be seen that the best results from the application of gypsum will be obtained from the application to soils containing potash in an insoluble form.

[1] Storer. Agricultural Chemistry. 1887. 1:206, 216, Quoted by Grimsley, Gypsum Deposits of Kansas, p. 127.

As an adulterant it is sometimes known as "terra alba" and is used in food and medical preparations.

In the calcined state, as plaster of paris, the uses of gypsum are too numerous to catalogue, but the greater part of the product is used in wall plaster and in wall washes. Dentists use large quantities in making plates, surgeons use it to hold broken limbs in place, and sculptors find it an invaluable material for making masks and casts. To the antiquary it is invaluable in taking impressions of inscriptions, statuary etc. It is used to some extent in the manufacture of wine to retard fermentation (the plastering of the wine) and absorb water. It has been discovered that blocks of plaster of paris are a good fireproofing material, because of the fact that it is a bad conductor of heat, being said to be superior to hollow brick.

It has ordinarily been supposed that the manufacture of slow setting, or cement, plaster is a new feature of the gypsum industry, but comparative analyses of the cement used in the building of the pyramid of Cheops and the modern cement plaster show a remarkable similarity in composition. Whether these two cements had the same chemical composition when prepared for use is a question, as slightly overburned or underburned gypsum will absorb water and return to the original condition, but much more slowly than gypsum that is properly burned. It is supposed by some that the cementing material of the pyramid of Cheops was slower setting than the cement plasters.

The difference between ordinary plaster of paris and a cement plaster is brought about by the addition of some retarding material to the plaster of paris, so that it will not set so soon, ordinary plaster of paris requiring only a few minutes to become hard, while a cement plaster requires from two to 24 hours to become thoroughly hard.

It is of interest to note that, whereas New York State plaster of paris was considered of no value but a few years ago, at the present time most of the mills have difficulty in filling their orders. With the increased use of gypsum cement plaster, the

old lime plaster is being largely driven from use. The slightly gray color of some of the New York State plaster was long urged as an insuperable objection to its use, but, when mixed with sand and fiber, it makes a superior wall plaster.

The advantages of cement plaster over lime plasters are, *first,* it sets more rapidly and dries out more rapidly than lime plaster, so that there is less delay in finishing buildings, *second,* as a nonconductor of heat, it is valuable as a fireproofing material, *third,* any desired tint can be given the plaster by mixing it with coloring material at the time the plaster is prepared for putting on the wall, *fourth,* less mortar is required to cover the same amount of wall space, *fifth,* it may be used in large slabs in wainscotings, as a substitute for marble and other ornamental stones, *sixth,* it is less liable to shrinkage than other plasters, so that few cracks are to be seen in the walls covered with this material.

Among the objections to the use of this plaster are its greater cost and the facility with which sounds are conveyed through walls of this material.

As just stated, the cement plasters have certain fireproof qualities, and these are increased by certain admixtures. Mixed with asbestos, it has been used in plastering the inside of firepots in stoves; in the walls and floors of fireproof buildings it has been used mixed with ashes and asbestos. In some cases the plaster of paris is mixed with wood fiber and other material and molded into blocks which resemble in form and appearance the hollow terra cotta fireproofing material. These are of course used in exactly the same way as the terra cotta.

The use of plaster of paris and the cement plasters in making ornamental ceilings and stucco work in general is becoming very widespread with the regulation of the set of the plaster. For this purpose, instead of laying the plaster on lath surfaces, the stucco is molded in the shop of the artist and is nailed or otherwise fastened to the timbers or girders of the walls or ceiling. The separate pieces are made in specially prepared molds of

glue, and fiber is added to give strength and toughness, while strips of wood are laid crosswise in the back of the larger pieces to give rigidity and in some cases to afford a better means of fastening the piece to the wall or ceiling.

A more recent development of the gypsum industry is the manufacture of wall boards made from alternating layers of paper and plaster of paris. The process of manufacture consists in spreading the properly moistened plaster of paris on the surface of a sheet of building paper, above the layer of gypsum is then placed another sheet of paper, and the two layers of paper and the one of gypsum are then passed between rolls, after which another layer of gypsum is spread above the second sheet of paper, a third sheet of paper is added and the rolling process continued. This operation may be repeated an indefinite number of times, but the usual practice is to have from five to seven layers of gypsum. When the board has passed from the machine where it is made, it is conveyed down a long table, where it becomes partially hard and is cut into the proper size for use. In order to give the material a chance to dry without warping, it is suspended from supports from the ceiling. When dry, the boards may be nailed to studs and rafters in the same way as boards or lath.

In the manufacture of glass, gypsum takes a very important part. In the uncalcined state it is said to be used as a constituent of certain kinds of glass. Its most important use, however, is in the calcined state, when it is used in plate glass factories to form a bed on which the glass is placed for polishing. In this way the strain is taken from the glass and there is little liability of breakage.

In monumental work, plaster of paris finds a similar use when it is placed about the stone to be polished, to form a bed for catching the water and polishing material.

The use of plaster of paris as a flux[1] is but little known, but in melting brass it is found to be superior to any known flux. It

[1] Sperry, E. S. Aluminum World, March, 1902.

melts easily, gives off no obnoxious fumes and is easily removed from the ingots. In practice it is the custom to use about 5 pounds of the plaster to every 100 pounds of brass.

Portland cement

A certain part of the plaster of paris made in this country is used in the manufacture of Portland cement. This use is legitimate up to 2%, but above that point it acts as a diluent, and the practice is to be condemned. The effect of plaster of paris on Portland cement is shown in the following, quoted from bulletin 44, New York State Museum.

The raw materials used in the manufacture of Portland cement may sometimes contain sulfate of lime in the form of the mineral gypsum, or sulfur may be present in the form of pyrite, which in burning tends to react with some of the carbonate of lime, yielding calcium sulfate. A similar effect may be caused if there is much sulfur in the fuel used. The effect of this sulfate of lime, if it does not exceed 2% or 3%, is to greatly delay the setting of the cement and also increase its final strength somewhat. If present to the extent of 4% or 5%, however, both these qualities disappear, since formation of calcic sulfid is brought about, which in turn reacts with the iron compounds in the cement and tends to disintegrate it. The effect of sulfate of lime is shown in the accompanying table, taken from Professor Johnson's work, *Materials of Construction*, p. 187.

The German association of Portland cement manufacturers has declared against any addition except up to the 2% $CaSO_4$ to regulate setting time. It is the general practice in the United States now to put in 2% $CaSO_4$ to produce slow set.

The following experiments are quoted by Lewis, showing the effect of sulfate of lime on the rate of setting.

No.	ONE SORT OF CEMENT	SETTING TIME		NEAT-CEMENT BRIQUET					BRIQ. 1 CEMENT, 3 SAND				
		h.	m.	7 days	28 days	12 weeks	25 weeks	1 year	7 days	23 days	12 weeks	25 weeks	1 year
1	As manufactured	0	20	323	405	518	620	700	115	168	238	302	360
2	Same w. .5 gypsum	3	30	315	456	572	623	650	142	212	339	353	390
3	1 gypsum	10	0	375	508	568	695	780	159	238	311	368	384
4	2 gypsum	14	0	423	543	688	718	805	180	263	305	375	410
5	No gyp. but kept in store for some months	10	30	318	450	550	592	618	168	218	318	360	431

These results were reported by John Grant in 1880.

MIXTURE	7 days	31 days	60 days	90 days
1–1 briq. average of 5........	107	159	188	267
1–1 briq. w. H_2SO_4 added to water: average of 5.......	129	227	260	255

Professor Tetmajer in 1894 reported these results.

No.	Per cent of plaster paris added	Strength of sand briq., 1 to 3 per sq. in. lbs. 3 days	7 days	28 days
4	......	......	160	240
	1	......	212	298
	2	......	167	254
5	......	174	285	307
	.5	225	305	344
	1	227	320	408
	1.5	230	381	399
	2	182	290	400
	2.5	184	295	390
	3	115	235	360

The results reported by Candlot in 1891 were as follows:

MORTAR	Days	SULPHATE OF LIME 0% lbs.	1% lbs.	2% lbs.	3% lbs.	4% lbs.
Neat cem. briq............	7	485	645	533	435	264
	28	673	738	674	790	483
1 cem. to 3 sand briq......	7	223	252	263	185	126
	28	333	377	377	367	201

Lewis considers these results remarkable as regards strength and not explained.

PROCESSES OF MANUFACTURE

About the middle of the last century the greater part of the best stucco for casts was made by the artists to secure the proper temperature in burning. In this way the artist was also enabled to make sure that the plaster had not lost its property of quick setting through absorption of water from the atmosphere.

Usually this calcining was done in small kettles over a domestic fire, and the gypsum was powdered before being cooked. In some cases the cooking was done on a metallic plate instead of a kettle.

Frequently the gypsum was baked in the baking oven,[1] or, as it is better known, a brick oven. In this case the rock was broken

[1] Knapp. Chemical Technology. Phil. 1849. 2:400–12.

to the size of an egg and spread out on the sole of the oven. Such an oven had no separate fireplace, but a fire was kindled on the sole, and, when the oven reached the proper temperature, the coals and ashes were removed and the gypsum was thrown in, and the door closed. From time to time pieces were taken out for trial, and, when they exhibited on the fractured surface only a few shining crystalline particles, the charge was removed and ground.

At Paris, where the manufacture of calcined gypsum, or plaster of paris, was for a long time carried on more extensively than in any other one locality, special plaster kilns or ovens were employed for baking the gypsum. The kiln was rectangular in form, covered with an arch and inclosed with side walls and also a wall at the back in which the chimney was erected. The front was left open for convenience in discharging and regulating the fire. The fireplaces were always constructed afresh in these ovens, and the largest lumps were used for this purpose, and smaller pieces were thrown on above. Wood fires were used in this kiln, and the smoke escaped through openings into the chimney.

In such an oven a certain percentage of gypsum was of necessity ruined, a part being overburned and another part being changed to calcium sulfid. A kiln very similar to the foregoing was used with coal as a fuel, but a special chimney was not used, and a grate of brick was built so as to permit the removal of ashes. The front was left open, but the gypsum was introduced through a door at the rear. Beneath the arches of gypsum were brick arches on which the coal was placed while the ash fell through the perforated bottom. The burning occupied from 12 to 16 hours when the lower layers were free from water. This type of kiln was open to the same objections as the earlier type, and a great proportion of the plaster was dead burnt, so that it would no longer set.

The kiln used by Scannegatty, though similar in some respects, is far better than the previous types, because the coal is not in contact with the gypsum, and the liability of forming calcium

sulfid is reduced to a minimum. The entire inner chamber is divided into two unequal parts by an arch, situated about a foot from the bottom. The upper part, into which the gypsum is introduced, is provided with eight draft holes. The lower chamber, or fire surface, is situated in front of the kiln. The draft channel terminates in the ash pit under the grate, on which a coal fire is made.

The flame enters below the perforated arch, where it is uniformly distributed over the whole area of the kiln in an upward direction through the gypsum, and makes its escape through apertures. The capacity of this kiln is given as 220 cubic feet of gypsum. Dumesnil's oven resembles Scannegatty's in form and in the manner in which the heat is applied, but would seem to be less economical of labor, though more heat is saved.

After the gypsum was calcined by any of the foregoing processes, it was reduced partially to powder, but the bulk of it had to be ground and sifted to separate the coarse particles.

In New York there are 18 mills engaged in the manufacture of land plaster and in the manufacture of plaster of paris from New York State gypsum. Two processes, the Cummer and the kettle, are employed in the manufacture of plaster of paris. So far as the land plaster is concerned, the process by which it is made is the same as the first steps in the kettle process of making plaster of paris.

The machinery used by most of the mills is made by Butterworth & Lowe of Grand Rapids Mich., and F. D. Cummer of Cleveland O.

Kettle process. As a rule, the crusher, which is usually an ordinary jaw crusher, is placed on the ground floor of the mill, so that the rock may be thrown directly from the wagon or car into the hopper. Pieces up to about a foot in diameter are reduced in this crusher to pieces of about 2 or 3 inches in diameter and are then taken to the nipper.

The nipper resembles an old-fashioned coffee mill, to a certain extent. The upper part, however, consists of a corrugated hopper in which a corrugated cone rotates, crushing the pieces of gypsum

to about the size of a hickory nut. The lower part breaks them up to about the size of peas, after which the fragments are elevated to a bin on the floor above. From this bin material is drawn through spouts to the burstones, which are usually on the same floor as the crusher. Other processes of grinding the gypsum have been introduced in other states, but so far the improvements have not been introduced into the mills of this State.

After the gypsum has been ground, it is elevated to the storage bin, which is located on the top floor of the mill, so that the kettles may be filled from it by merely opening a gate and letting the plaster run by gravity from the bin. The kettles consist of cylinders of boiler steel, usually 8 feet in diameter and 6 or 8 feet deep. Such a kettle is estimated to hold 10 or 12 tons, though usually the charge is not more than 8 tons.

For greater strength the bottom of the cylinder is convex upward and is thicker than the sides. The kettle is placed on a brick foundation and is enclosed in a brick jacket with an air space between, which serves as a flue. Two flues pass through the kettle, so that more heat is saved on account of the greater surface exposed to the heat. The gypsum is stirred from the time it is first put into the kettle till the charge is withdrawn by the two arms near the bottom of the kettle, which are fastened to a vertical shaft, which is set in motion by a pinion wheel. The plaster is fed gradually into the kettle, because, if it runs too rapidly, the gearing may be broken and the plaster burned on the bottom. It takes about an hour to fill the kettle, and in a short time the temperature of the plaster reaches the boiling point of water, and part of the water of crystallization begins to pass off. When the temperature reaches about 235° F., the mass boils furiously, and the temperature gradually increases to about 260° F., when the vapor ceases to pass off and the plaster settles into a solid mass. When the temperature rises to about 290° F., the boiling begins again, and the plaster continues to give off water till the temperature of 350° F. is reached, when it settles again. At this point a gate is raised, the plaster rapidly discharged into a bin on the ground and the kettle again refilled.

The plaster is now bolted or screened, and the coarse particles are reground in burstone mills.

The Cummer process. The first stage in this process is the same as the first stage of the kettle process: i e, crushing in a Blake crusher to about the size of a hickory nut. Usually a nipper is not used, but the rock is screened after being crushed, and pieces that are larger than the desired size are returned to the crusher and broken again. In some mills gyratory crushers are used, and, where a large quantity is to be crushed, these are probably more economical than the jaw crushers.

The crushed rock is elevated by a bucket elevator to the storage bin, from which it is drawn by gravity to the calciner, which consists of a cylinder of boiler steel about 27 feet long and 4 feet in diameter, which revolves over the fire. The fire is usually fed by self-stoking machinery, and the smoke passes through the cylinder, so that as much heat may be saved as possible. The cylinder is inclined slightly, so that the material rolls from the inlet to the other end, where it is taken by a bucket elevator to the cooling bin. When the material in the bin becomes cool enough, it is withdrawn through gates at the bottom and conveyed to the mills in which it is ground. In the plants using the Cummer process, emery mills are used in place of burstones, because they do not require redressing so often. After passing through the emery mills, the plaster is screened and the larger particles are returned to the mill to be reground.

TECHNOLOGY OF GYPSUM

Though, as heretofore stated, the use of gypsum as a cementing material was known at an early date, and its application to the soil as a fertilizer was also known, yet the most of the properties of this material, together with its chemical composition, were unknown and had never received any investigation. The discoverer of the composition of gypsum was Lavoisier, who in 1765 published the results of his experiments in the Proceedings of the Académie des Sciences. After decomposing the gypsum rock and discovering the chemical composition, Lavoisier produced gypsum by synthesis.

Physical properties of gypsum. Sufficient has already been said about most of the physical properties of gypsum [p. 91 et seq.], but the results of recent experiments render it necessary to go more deeply into the subject of the solubility of gypsum.

A table has already been given showing the results obtained by Marignac, and, for the average reader as well as the author, it will seem more practical than the more recent table which has been prepared to show the number of millimolecules of gypsum in a liter of a normally saturated solution. The results of Poggiale, Marignac and Droez have been calculated to millimolecules per liter.

Temp.[1]	Poggiale	Marignac	Droez	Normally saturated solutions Hulett and Allen
0°	15.06	14	.....	12.91
5.5	.....	.....	14.11	13.56
14.2	.....	.....	14.83	14.50
18	.....	15.06	.....	14.81
19.5	.....	.....	15.66	14.88
20	17.72	.....	.....	14.95
24	.....	15.30	15.87	15.23
32	.....	15.64	.....	15.38
35	18.75	.....	.....	15.40
36	.....	.....	16.19	15.41
38	.....	15.79	.....	15.41
41	.....	15.71	.....	15.39
53	.....	15.52	.....	14.85
72	.....	14.86	.....	12.70
86	.....	13.94	.....	12.70
99	.....	12.89	.....	11.95
100	.....	.....	.....	11.90

Lavoisier discovered in his experiments that, on heating gypsum, water was removed at two different stages, and furthermore that, while it was a simple matter to remove three quarters of the water, it required more time and much higher temperature to force out the remaining quarter.

In 1830 these results were confirmed by Payen, who found that water commences to pass off at 115°C., and that the loss

[1] Hulett, George A. & Allen, Lucius E. The Solubility of Gypsum. Jour. Am. Chem. Soc. July 1902. v. 24.

continues up to 204°C. The most extensive experiments, however, were probably made by Le Chatelier.[1] As a result of these experiments, it was discovered that from the boiling point of water up to 200°C., the rise in temperature was constant with two exceptions. The first halt occurred at 128°C., the second at 163°C. From this fact and the fact that water ceased to pass off at these stops, he inferred that there are two different hydrates which are decomposed before any rise in temperature takes place.

In order to prove the existence of two hydrates, Le Chatelier heated a saturated solution of gypsum in a closed tube to a temperature between 130°C. and 150°C. As a result, delicate rectangular prisms were formed, which, when analyzed, gave the following result:

Water	6.7
Sulfate of lime	93.3
	100

A result was obtained in this way which corresponds very closely to an analysis of the incrustation in the boilers of ocean steamers, in which the analysis made by Le Chatelier was as follows:

Lime carbonate	.3
Iron oxid	2
Water	5.8
Lime sulfate	91.9
	100

These results both agree very closely with the formula $(CaSO_4)_2\ H_2O$, which would show the analysis

Water	6.2
Sulfate of lime	93.8
	100

[1] Le Chatelier. On the Dehydration of Gypsum stone and the two Compounds Formed. Académie des sciences. Comptes rendus. 1883.

Set of plaster. Lavoisier, Landrin, and Le Chatelier all gave theories to show the cause of plaster of paris setting or becoming solid.

Lavoisier's theory, as quoted[1] by Grimsley from the original account, is as follows:

I took the calcined plaster, as has been described before, and which hardens readily with water. I threw it into a considerable amount of water, in a pan or in a large dish. Each molecule of plaster, in passing through the liquor, seized its molecule of water of crystallization and fell to the bottom of the dish in the form of small brilliant needles, visible only with a strong lens. These needles, dried in the free air or with the aid of a very moderate heat, are very soft and silky to the touch. If placed on the stage of a microscope, it is perceived that what was taken under the lens for needles are also parallelopipeds, very fine, so they are described as thicker, or many thinner, and many more elongated. The plaster in this state is not capable of uniting with water, but if it is calcined anew, these small crystals lose their transparency and their water of crystallization, and become again a true plaster, as perfect as before. One may in this fashion successfully calcine and recrystallize the plaster, even to infinity, and consequently give to it at will the property of seizing water.

Landrin's[2] theory, which is the result of an elaborate study of plaster, divides the set into four periods:

1 The calcined plaster, on contact with water, unites with this liquid and takes a crystalline form.

2 The plaster dissolves partially in the water, which becomes saturated with this salt.

3 A part of the liquid evaporates, due to the heat set free in the chemical combination. A crystal is formed and determines the crystallization of the entire mass; a phenomenon which is analogous to that which takes place when a piece of sulfate of soda is placed in a saturated solution of this salt.

4 The maximum hardness is reached when the plaster loses enough water to correspond exactly to the formula SO_3CaO, $2H_2O$; this maximum being to the remainder in proportion to the quantity of water added to the plaster to transform it into mortar.

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[1]Landrin. Annales des chimie. 1874. p. 434, 435. Also Grimsley Gypsum Deposits of Kansas, p. 90.

[2]Landrin. Annales des chimie. 1874. Also Grimsley Gypsum Deposits of Kansas, p. 91.

Le Chatelier's theory. Le Chatelier showed that Landrin's third principle as mentioned above was not necessarily true, inasmuch as plaster would set in a vacuum flask.

His own theory was that plaster of paris partially dissolves in the water, thus diminishing solubility, the solution becomes supersaturated and gypsum crystallizes out.

Grimsley's theory. Grimsley[1] noted that, "when water is added to the calcined plaster, small needle-like prisms are seen forming and shooting out here and there. As these become more and more abundant, they unite with one another and rapidly form a solid mass, in which the individual crystals can scarcely be distinguished. Open spaces are left in the mass apparently filled with water, and finally these are closed, and a firm solid mass results."

He also noted that crystallization was more rapid in the finer grained plasters than in the coarser ones. He agrees with the investigators mentioned above that the setting of plaster is due to the formation of a crystalline net-work, but his explanation of the cause of the formation of this net-work is somewhat different, and a summary of the same is given below.

1 When water is added to plaster of paris, the plaster becomes partially dissolved.

2 When the solution becomes hydrated and supersaturated crystallization is started, and the liquid becomes turbid.

In explanation of this theory, Grimsley says:

The solution of the hydrate in these experiments is certainly saturated, and all that is needed is something to start the crystallization. From a study of saturated solutions in the laboratory, it is well known that if crystals are introduced into such solutions, crystallization will result and go on until the salt has crystallized out.

The effect of heat on gypsum in the burning of plaster is to remove a certain percentage of water, and to break up the small masses of the rock into finer and finer particles, microscopic and even ultra-microscopic in size. If the heat has not been carried too far, certain particles through the mass may still possess their crystalline form, and so they are true crystals, though very small. These minute crystals in the saturated solution

[1] Grimsley, G. P. & Bailey, E. H. S. Special Report on Gypsum and Gypsum Cement Plasters. Univ. Geol. Sur. of Kan. Topeka 1899. p. 92–96.

would start the process of crystallization. Their growth would cause the turbidity of the solution noted by Marignac, and would result in a precipitation of small gypsum crystals, thus forming a crystal net-work which constitutes the set of plaster.

If the plaster is underburned the gypsum is not reduced to its proper fineness and uniformity, and so would not permit the crystallization to go on in the way it would in the properly burned plaster. But of more importance the hydrate represented by plaster of paris would not be formed.

If the plaster is overburned, the plaster will be so completely comminuted that no minute crystals will be left to start the crystallization. Where the plaster is slightly overburned, the crystals are extremely fine and crystallization goes on very slowly and imperfectly.

Retarders. The question of retarding the set of plaster of paris is one that has received a great deal of attention in the past few years, and the substances which are used are almost too numerous to mention. The principal materials used are different forms of organic matter, as glue, starch and animal refuse. These when moistened form a gelatinous liquid, which hinders the formation of the crystals.

The carbonates of the alkaline earths are sometimes used to dilute the plaster. Slaked lime or calcium hydrate is used to make a lime plaster putty, which sets quite slowly and is used largely in the manufacture of relief forms for ornamentation.

As a usual thing, the addition of any material which is not a stronger cementing material than the plaster of paris will have a tendency to render the hardened plaster weaker than it would be in the pure state. It is possible, however, that even the addition of material that may be considered a diluent may give hardened plaster that will be fully as strong as the pure material would be, if not stronger. Experiments have not been made with a view of ascertaining the truth of this, but the ultimate strength of the hardened plaster seems to be due to the filling of all crevices in the material and the addition of a material which helps to fill the crevices should have this effect.

It is known that in the manufacture of Portland cement, equal portions of cement and sand can be ground together, and the

resulting mixture when moistened gives better results in tensile strength than pure Portland cement.[1] This is due to the fact that the particles of sand afford surfaces to which the cement may adhere.

The retarders used by most of the plaster manufacturers consist of a mixture of various materials, and some of the mixtures appear almost ridiculous. The essential constituents however are certain forms of organic matter, among which are included glue, glycerin, sawdust, sugar, oils, paper pulp, flour pack, fiber, oil meal, molasses, Irish moss and tankage. The inorganic materials consist largely of different salts of the alkalis and alkaline earths, acids and other forms of cement.

The ultimate strength of a retarded plaster will depend largely on the changes that will take place in the material used to retard the set. Many of the organic materials mentioned above would undoubtedly decompose to a certain extent. If present only in small quantities, their effect on the strength of the plaster would probably be very slight, but the presence of any material which is likely to decay is of no advantage to the plaster, not only from a consideration of strength but also from a sanitary standpoint. Great care should therefore be taken in the selection of an organic retarder.

The addition of a good mineral retarder, however, is likely to prove an advantage, as the fact that the set is retarded gives strength to the supposition that the resulting network of small crystals will be much stronger because of the length of time required for the set. It has been shown [p. 125] that, in the manufacture of Portland cement, the addition of gypsum in quantities not over 2% of the whole, increases not only the time required for setting but the ultimate strength of the cement.

It has also been shown[2] that there is apparently a definite relation between the length of time required for setting and the tensile strength, and up to a certain point those cements which

[1] Newberry, S. P. Eng. News, Ap. 16, 1896. p. 252.

[2] Ries & Eckel. Lime and Cement Industries of New York, pl. 91 to 98 inclusive.

Plate 1

Gypsum quarry of F. M. Severance, Fayetteville N. Y.

require the longest time for setting show the greatest strength. This seems to give some ground for the supposition that retarding the set does not decrease the strength. It also shows that a material which of itself may not be as strong as the material whose set is to be retarded, may give increased strength to the retarded material.

Accelerators. It is sometimes necessary to hasten rather than retard the set of plaster, and in order to do so, some other crystallizing salt as alum or borax is added in small quantity to the plaster. When moistened, this salt has a tendency to crystallize and starts that process in the plaster of paris. A dish which has been used in making plaster of paris will have a tendency to accelerate the set because of the crystals already formed.

New York mines and mills

Cottons. At Cottons an open quarry is worked by Mr R. D. Button. Ordinary black powder is used as the explosive, and the entire output is used in the manufacture of land plaster. An analysis[1] of the rock follows:

Sulfate of lime (pure gypsum)	82.66
Carbonate of lime	6.569
Carbonate of magnesia	5.075
Iron oxid and alumina	1.837
Insoluble matter and moisture	3.859
	100

The greater part of the rock is ground at Perryville by Mrs Hattie C. Hodge.

Fayetteville. The quarries at Fayetteville are located about 2 miles southwest of the village and are situated on two knolls.

Four companies have quarries here: the National Wall Plaster Co. and the Adamant Wall Plaster Co. of Syracuse, Mr F. M. Severance and Mr C. A. Snooks of Fayetteville.

All these quarries were at one time owned by the Onondaga Gypsum Co., which was formed in 1878 and operated as a plaster

[1] Analysis furnished by R. D. Button.

trust. After three years the company was dissolved, and the property went into other hands.

The oldest quarry is that of Mr Severance, which has been worked since 1812. The bed of gypsum in this quarry is about 60 feet thick and consists of eight layers varying in thickness from 18 inches to 30 feet. It is covered with about 40 feet of shaly rock, together with hydraulic limestone.

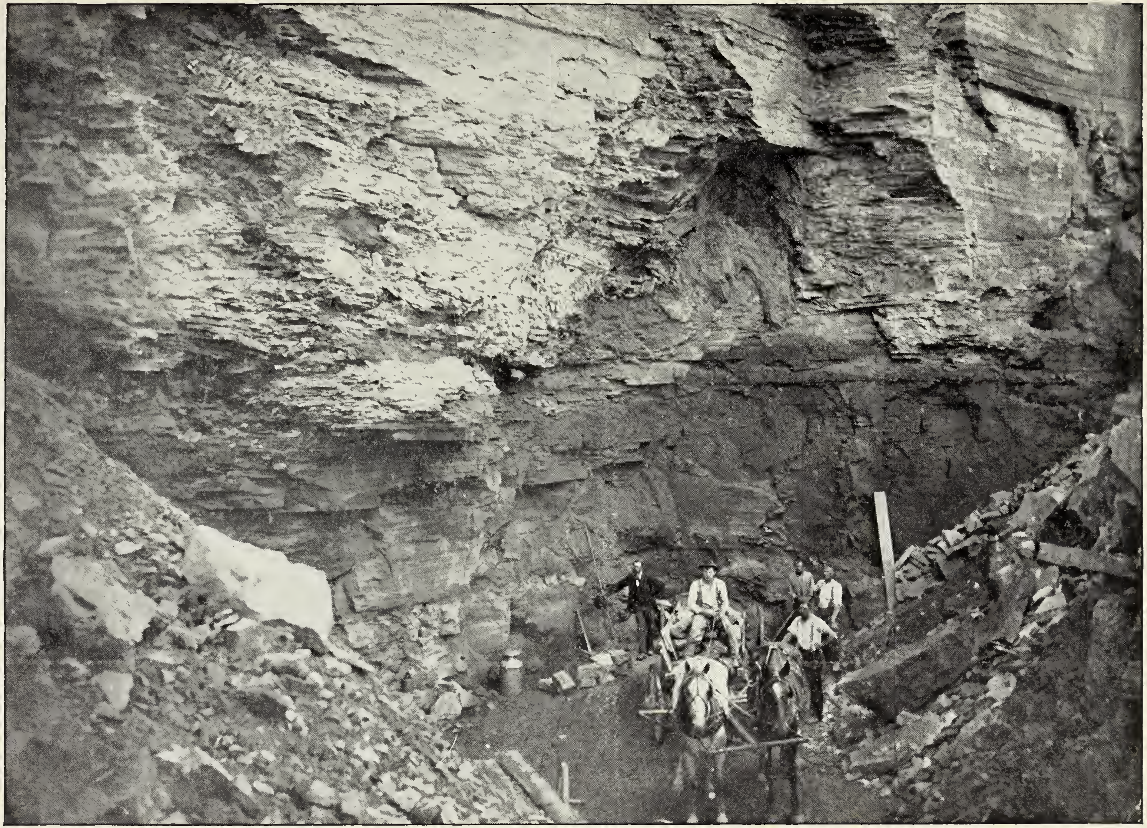
The plaster rock varies in color from light drab in the cap to a dark brown (iron layer), all forms becoming lighter on exposure to air. The so called "slate" consists of fibrous, scaly, and other forms of gypsum; the remaining beds consist almost entirely of compact gypsum.

The specific gravity varies from 2.68 in the 9 foot layer to 2.33 in the slaty layer.

The composition is nearly uniform, consisting of gypsum from 80% to 90%; calcium carbonate, a trace; magnesium carbonate, 5% or less; clay, 10% or less. The amount of carbonates is greatest in the iron layer, showing effervescence in the mass. It is nearly as abundant in the cap layer; it is least in the crystalline layer (the so called *slate*); but in none of the layers is the quantity sufficient to prove detrimental. To quarry this gypsum, the slate rock above must be stripped. This stripping is accomplished after a portion of the quarry has been worked out, by blasting out a layer of shale about 4 feet in thickness immediately above the plaster rock. When sufficient has been blasted, the overlying *slate* falls down into the hole from which the gypsum has been removed, and the new part exposed can be quarried without removing very much of the strippings. Mr Severance claims that in this way he has to remove only about one third of the stripped rock.

When quarrying the gypsum, three beds are recognized by the quarrymen. The upper bed is the lightest of the three and is about 30 feet thick. The lower beds are of darker color, showing more marked strata of light and dark gypsum, and are said to be richer in sulfate of lime.

Plate 2



Gypsum quarry of F. M. Severance, Fayetteville N. Y.

The local mills are furnished with gypsum rock in the winter time, and the outsiders during canal navigation. The rock has to be hauled about 1½ miles to the canal. The quarry is operated the year round. The cost of mining is about 25c to 30c a ton, and the rock sells, delivered at the canal or to the local mills, for 90c a ton. From four to 12 men are employed at the quarry, according to the demand for gypsum.

Immediately adjoining Mr Severance's quarry are the quarries of the National Wall Plaster Co., which are in the same deposit as the foregoing. The method of quarrying, however, differs in some respects. The gypsum is quarried so as to cut under the overhanging rock, which then falls into the place from which the gypsum has been taken. This necessitates moving a greater amount of rock than the method employed by Mr Severance. In these quarries dynamite and Climax blasting powder are used. From 12 to 20 men are employed at the quarries. In the strippings some hydraulic limestone is found, which is sold to cement manufacturers.

The beds owned by the National Wall Plaster Co. occupy about 5 acres. At this company's mill, which is located on the bank of the canal, about 1½ miles from the quarry, the Cummer process of calcining the gypsum is employed. About a year ago two kettles made by Butterworth & Lowe were set up in this mill. The equipment of the mill consists of one Blake crusher, one calciner, one cooling bin, two kettles, two Sturtevant emery mills. The capacity of the mill is seventy-five tons a day. The product is used in wall plaster but a large portion of it is sold to Portland cement manufacturers. A large part of the product that goes to the Portland cement manufacturers is not ground after passing through the calciner, but is shipped as it comes from the kiln and is mixed and ground with the cement.

On the east of the National Wall Plaster Co.'s beds and south of those owned by Mr Severance is located the property of the Adamant Wall Plaster Co. This company owns about 19 acres

of ground, about 15 of which are underlain by gypsum. This property is not worked at present, and the company is using calcined plaster from Oakfield N. Y.

The quarries of Mr C. A. Snooks occupy about 3 acres. The beds are about the same as those on the adjoining hill. The product is used by local mills entirely.

Jamesville. In the quarry of E. B. Alvord & Co., of Jamesville, the rock is quarried by the use of hand drills. The explosive used is black powder. The mill has a capacity of about 25 tons in 10 hours. The equipment consists of a cracker and burstone mill. The power is furnished by a 70 horse power turbine. This mill has been run by the present owners since 1869, but the date when gypsum was first dug at this place was much earlier. The entire product of the quarry is used for land plaster.

Marcellus. Near the station a small quarry is worked by Mr Walker. The product is used entirely in the immediate locality. The annual output does not exceed 500 tons.

In grading for a trolley line from Marcellus station to the village an outcrop of plaster rock was exposed in 1900 near the station. The outcrop is about 20 feet thick and extends along the road about 160 feet. The rock shows layers of white fibrous gypsum at intervals ranging from 3 to 12 inches. These layers are from $\frac{1}{4}$ inch to 1 inch in thickness. The main rock does not seem so solid as the material found at Union Springs and Fayetteville, but should make a fair land plaster. The bed seems to be quite extensive, judging from the fact that it is found at the same horizon just across the valley. Outcrops of the same bed are to be seen between Marcellus Station and Fairmount in the hill at the south of the railroad, and it is said that many thousand tons of this material were taken out when the New York Central Railroad was being put through.

Syracuse. Two and one half miles south of Syracuse gypsum was formerly quarried by A. E. Alvord, but the bed became exhausted, and no work has been done since 1901.

Phelps. Mr A. D. Miller has for many years operated a quarry at this place; his only product is land plaster. The quarry is on

Plate 3

Gypsum quarry of F. M. Severance, Fayetteville N. Y.

Canandaigua outlet and is well exposed; so the quarrying operations are easy.

Victor. A quarry and mill for the manufacture of land plaster are owned at this point by Mr Theodore Conover.

Port Gibson. At Port Gibson are the quarry and mill of Mr Ezra Grinnell. The rock is well exposed in the bed of the stream at this place, and, the water having been diverted for mill purposes, the bed of the stream is left dry, so that it is easy to quarry the gypsum. For several years the work at this place has been intermittent, and at present only a local trade is supplied with land plaster.

Union Springs. The first mining of gypsum at Union Springs was probably commenced while the Erie canal was being built. As early as 1822, Robinson, in his catalogue of localities of American minerals, states that several thousand tons of gypsum were shipped annually from this point to Pennsylvania.

At present the only quarry of importance at this location is that of the Cayuga Land Plaster Co. The plant is about a mile or a mile and one half north of Union Springs, on the line of the Lehigh Valley Railroad, near the junction of the Cayuga branch and the Auburn branch. The quarry is about an eighth of a mile from the mill, and the material is hauled in carts to large drying sheds adjoining the mill. The stripping at this quarry varies from 2 or 3 to 20 or 25 feet of earth, there being very little rock overlying the gypsum, though in one or two places a few feet of waterlime have been observed. The dirt is stripped and carried to the dump, though a few years ago the stripping was much simplified by the Lehigh Valley Railroad Co., which ran a switch to the quarry and took this overburden of earth for filling along its line.

Power drills have not been introduced at this quarry, but the old jumper drill still holds its own. The explosive used is black powder. The mill equipment of this company consists of one Blake crusher, one cracker or nipper, and five burstone mills.

An analysis of the plaster made for this company shows

Sulfate of lime	80.78
Carbonate of lime	1.76
" magnesium	3
Phosphate of lime	.43
Sand	3.32
Organic matter	.18
Chlorin, potash and clay	10.05
Total	99.52

The general color of the gypsum rock when first quarried is a dark gray, but on exposure to the air, it becomes very much lighter. Occasionally plates of selenite intermingled with impure rock are found, and at times well formed crystals and large plates of selenite are encountered.

In this vicinity are several old quarries which are not worked at the present time.

Garbutts. At Garbutts are located the mines and mill of the Lycoming Calcining Co., which began operations at this place in 1900. Before that time a mine was operated by Mr John Garbutt for many years, and the output was disposed of entirely in the form of land plaster. The old mine was reached by a shaft; but, with the beginning of work by the new company, a tunnel was driven into the gypsum from the bank of Allen's creek, and the creek was bridged so that the cars could be hauled directly from the mine to the mill. There are three deposits of gypsum with intervals of about 6 feet between them. Two mines have been opened into the upper deposit, and recently a tunnel has been driven into the second bed. The waste rock is carefully corded up in the mine in such a way as to help sustain the roof, so that a larger proportion of the gypsum can be removed than could otherwise be taken out. The quality of the gypsum is the same as that of the Wheatland rock, and little difference can be detected between this rock and the product of the mines at Oakfield and Indian Falls.

In calcining the gypsum the Cummer process is used, and the equipment of the mill consists of a Butterworth & Lowe crusher, one calciner, four coolers and four Sturtevant emery mills. Difficulty was experienced at first in securing a satisfactory product, but certain modifications have been brought about in the process, so that a ready market is secured for the entire product. The Diamond Wall Cement Co. uses a large proportion of the product in the manufacture of cement wall plaster, and recently (December 1902) the Sackett Wall Board Co. has commenced the manufacture of its patent wall board in a large building near by, in which it uses about 150 tons of stucco each week.

Wheatland. About 3½ miles east of Caledonia are located the mines and mills of the Wheatland Land Plaster Co. The mine is located in a knoll and is entered by a tunnel. The gypsum deposit is about 6 feet thick and consists of three distinct layers, the best being in the middle. The drills used are hand power, Howell twist drills, and the explosive is dynamite. In taking out the gypsum, pillars are left which range in size from 15 feet in diameter to 30 x 75 feet according to the condition of the roof.

Timbers are used in all parts of the mine. The rock is hauled from the mine on cars holding about a ton. The floor of the mine is about on a level with the mill, which is on the opposite side of Allen's creek, so that the cars can be hauled directly from the mine to the mill. The mills consist of two buildings. In the nearest one to the mine are a Blake crusher and two burstone mills. In the other building, which is much larger, are a nipper and two burstone mills.

When the rock is brought from the mine, the cars are halted at the first building and the larger pieces thrown into the crusher, in which the rock is reduced to about three quarters of an inch in diameter. The smaller pieces of rock are then taken to the second mill and run through the nipper. Most of the plaster from these mills is shipped in bulk in carload lots. Some of it, however, is used in the manufacture of an insecticide.

A second deposit has recently been opened up, about 6 feet below the first, which is said to show over 90% gypsum.

Oakfield. Two companies, the United States Gypsum Co. and the Oakfield Plaster Manufacturing Co., are engaged in mining and calcining gypsum at Oakfield.

The United States Gypsum Co. is the larger of the two and operates the mines and mills formerly worked by the English Plaster Co. and the Genesee Plaster Co. This company was formed in the winter of 1901-2 and controls factories in Michigan, Iowa, Kansas and Oklahoma as well as New York. In addition to the plants mentioned above, the Buffalo Mortar Works and the Big Four Wall Plaster Co. were taken into the combine.

For many years Mr Olmsted mined gypsum and manufactured land plaster at Oakfield, and about 1892 he put in one kettle to make plaster of paris. So far as is known, this was the first attempt to calcine New York gypsum on a large scale, and it was successful from the outset. Subsequently the property was purchased by the English Plaster Co., and a new plant was erected. The equipment of this mill consists of one Blake crusher, one nipper, five kettles and five burstone mills. Two mines supply the rock for this mill. These mines are about 40 feet deep, and the rock is hoisted by steam power. The bed of gypsum is only about 4 feet thick, but it is said that about 80 feet below this deposit is another bed about 10 feet thick, but this has not been developed, nor is anything known concerning its quality.

Water gives a great deal of trouble in the mines, and one of them has to be abandoned in the winter because of the difficulty and expense of pumping the water. Howell twist drills are used to make ready for the blasts, and black powder is the explosive used.

The mill formerly owned by the Genesee Plaster Co. is the most convenient one in the State using the kettle process. To the regular calcining equipment has been added the machinery of the Big Four Plaster Co., which was formerly located in the

village, so that the entire equipment consists of one Blake crusher, one nipper, eight burstone mills, four kettles, two shaking screens, one single mixer, one triple mixer and one sand drier. The power for running the machinery is furnished by a 250 horse power cross compound engine.

At the west end of the mill is a large rock shed, where in slack times the surplus rock is stored. When the mill is running to its full capacity, it takes the full output of the mine to keep it running. The plaster rock for this mill is obtained from two mines about a half a mile north of the mill. They are entered by a vertical shaft, and the rock is raised from the mines by two 50 horse power hoisting engines. Howell twist drills, run by compressed air, are used, and an automatic air compressor at each mine furnishes the requisite power. The blasting is all done with black powder. At the east end of the mill is the sand bed where the sand for the *Big Four wall plaster* is stored and dried. This sand is brought from the pit, which is about a quarter of a mile northeast of the mill, by a tramway, and after it has been dried and screened, it is put in a storage bin, from which it is taken, as required, to the mixers. As noted in the statement of the equipment, there are two mixers, one single and the other triple. The first of these is used in mixing the hard wall plaster which is sold under the name of *Ivory wall plaster*, while the triple mixer is used in the mixing of the sand and fiber plaster known to the trade as the *Big Four wall plaster*.

On the third floor of the mill is a testing laboratory for testing the strength of the plaster. Samples of every shipment are tested, and the record, as well as a duplicate sample of the material, is kept, so that the company is able not only to know that satisfactory material is being shipped, but, in case of complaint, to prove the quality of the material when shipped. The results of the tests for tensile strength made in the laboratory are possibly somewhat lower than they should be, because there is a great deal of vibration in this part of the mill, which has a tendency to cause the briquets to break sooner than they otherwise would.

Average results for one day		range from	150 to 170	pounds
"	20 days	"	250 to 280	"
"	30 "	"	340 to 410	"

A test of samples sent from this mill was made by the city surveyor of Utica N. Y., with the following results.

1 day	 93	pounds
2 days	 210	"
5 "	 300	"

At present no plaster is calcined in the English mill on account of the superiority of the arrangement of the new mill, but this mill is used entirely in grinding land plaster and the kettles are kept ready only for emergencies.

The mill of the Oakfield Plaster Manufacturing Co. is about 2½ miles west of Oakfield, adjacent to the West Shore Railroad tracks. The equipment consists of one Blake crusher, two burstone mills, two kettles and one bolting cloth. A large rock shed in which surplus rock may be stored is on the north side of the mill just outside the crusher room.

The various stages in the manufacture are the same as in other kettle mills, but bolters are still used instead of the more economical shaking screens. Above the kettles in the steam flue are two dust chambers to collect the fine plaster which is driven off in the cooking.

The mines of this company, three in number, have vertical shafts, and the rock is hoisted by horse power. The rock is hauled to the mill in wagons. Much trouble is experienced in these mines on account of water, which is more troublesome in the winter than in summer, so that almost all the mining must be done in the summer, because of the impossibility of getting rid of the water except with powerful steam pumps. On the occasion of the author's visit the mill was closed.

Indian Falls. About a mile and a half from the village of Indian Falls on the Tonawanda Indian reservation are the mines of the Standard Plaster Co. of Buffalo. A railroad has been built by the company from the mines to the West Shore Railroad

a little west of Alabama, and the rock is shipped to the company's mill at Black Rock.

About 6 feet of good gypsum are mined, while overlying this are about 8 feet of an impure gypsum, which is too hard for use.[1] Above this upper bed of gypsum is a crumpled deposit of impure limestone, which is much broken up. The gypsum rock is found outcropping along the creek for more than half a mile and is about 30 feet above the creek, so that it is mined by tunnels, and the rock is loaded directly from the mine cars onto the railroad cars for shipment. Intermittent mining has been carried on at this place for years, but no work of any importance was undertaken till the summer of 1901, when the Standard Plaster Co. secured the mining right for the entire reservation and opened its first tunnel.

The only great difficulty encountered in mining the gypsum is caused by the mud pockets described in a former chapter [p. 110]; but this difficulty is likely to grow less as the overburden becomes greater, and the chance of surface water reaching the deposit becomes less. Howell's twist drills are used in drilling the rock, and both hand and power drills are employed. The power is furnished by an automatic air compresser for the air drills, and black powder is used in blasting. The rock is loaded on small flat cars, holding about a quarter of a ton, which are pushed to the entrance of the mine, where the rock is sorted, the good rock being thrown into the railroad car and the waste being thrown over the bank of the creek.

The mill of this company is located on Dart street and Scajaquada creek, Black Rock. The equipment consists of a gyratory crusher and screen, one Cummer calciner, one cooling bin and five Sturtevant emery mills.

The power is furnished by two electric motors of 100 horse power and 250 horse power respectively, which are run by electricity

[1] It is probable that this upper layer is anhydrite as after this report was prepared the deposit in the Lehigh shaft at Leroy which was supposed to be gypsum was reported by Mr Charles Root of Caledonia to be anhydrite. The greater hardness and the higher percentage of $CaSO_4$ would indicate this mineral.

brought from Niagara Falls. In order to prevent the escape of dust from the calciner, a stream of water is sprayed on the smoke and dust at the top of the flue, which is turned downward, and as a consequence the coat of plaster of paris, which is so common around other plaster mills, is entirely lacking here.

For some time hollow fireproofing blocks similar to the hollow brick used for partitions in fireproof buildings, were made here, but the demand for stucco has been so great that this branch of the industry has been temporarily discontinued.

Akron. At Akron a shaft has been sunk, and it is expected that gypsum will be mined shortly. Up to the present time, however, nothing has been done.

Production of gypsum in New York

The production of gypsum for New York since 1889, was as follows:

Year	Product		Value
1889	52608	short tons	$79476
1890	32903	"	73093
1891	30135	"	58571
1892	32394	"	61100
1893	36126	"	65392
1894	31798	"	60262
1895	33587	"	59321
1896	23325	"	32892
1897	33440	"	78684
1898	31655	"	81969
1899	52149	"	105533
1900	58890	"	150588
1901	119565	"	241669
1902	110364	"	259170
1903	137886	"	462383

ANALYSES OF GYPSUM

The following table of analyses of gypsum is compiled to show the comparative merits of the great deposits of this country. It has been somewhat difficult to obtain satisfactory analyses of New York State gypsum, as few samples have been

analyzed except for manufacturers, and in many cases the writer is compelled to admit that little dependence can be placed on analyses made for the sale of materials. A comparison of the circulars sent out by different firms several years ago, shows the material advertised as containing from 80% to 90% of pure gypsum, while the material sold by competitors is represented as containing from 60% to 80%. It is safe to say, however, that the average product from the principal working deposits will run from 70% to 75% gypsum.

	1	2	3	4	5	6	7	8	9
Gypsum	82.89	81.5				94.84	94.56	87.81	96.46
SiO_2 and insol	4.3	5.3	2.8	.15	6.43	1.88	2.67	.99	2.57
Other matter						4.28	2.77	11.2	.97
CaO			31.87	32.44	29.41				
MgO									
K_2O									
CO_2									
SO_3			45.76	46.61	44.19				
H_2O			19.9	20.74	20.18				
Al_2O_3	3	2.41	.6		.64				
Fe_2O_3	.21	.25							
$CaCO_3$	9.8	9.47							
$MgCO_3$	.79	.59							
$CaSO_4$									
	100.99	99.52	100.93	99.94	100.85	100	100	100	100

	10	11	12	13	14	15	16	17	18	19	20
Gypsum	74.09	64.53	73.92	82.5	82.66		78.44		70.73	94.03	
SiO_2 and insol	6.05	11.17	4.64		3.859	.91	.65				
Other matter	19.86	24.27	21.44	12.15						5.97	
CaO						32.35		32.88			
MgO						.54					
CO_2											
SO_3						46.38		45.79			
H_2O						19.7	20.76	20.98			
Al_2O_3					$\left.\begin{matrix} \\ \end{matrix}\right\}$ 1.837	.6					
Fe_2O_3											
$CaCO_3$				1.75	6.569						
$MgCO_3$				3.6	5.075						
$CaSO_4$											
					100	100.48	99.85	99.65			

	21	22	23	24	25	26	27	28	29	30	31	32	33
Gypsum	88.8	88.9	83.2	72	87	72.6							
SiO_2 and insol	2.2	1.4	4.8	14.3	13	6	.35	.65	.4	.35	1.18	.52	.19
Other matter				9.8									
CaO							32.44	33.51	32.28			32.28	32.53
MgO							.12	.19	.17			.98	.16
CO_2												1.90	.81
SO_3							46.24	46.65	45.96			44.61	45.73
H_2O							20.52	18.84	20.36	19.96	20	19.47	20.46
Al_2O_3							.12	.17	.19	.12	.15	.26	.1
Fe_2O_3													
$CaCO_3$	9	9.7	12	3.9		22				.56	.36		
$MgCO_3$										.57	.52		
$CaSO_4$										78.4	78.04		
										99.96	100.25	100.02	99.98

	34	35	36	37	38	39
Gypsum						
SiO_2 and insol.	.55	10.67	12.13	8.78	2.17	2.9
Other matter						
CaO	32.64	30.2	29.14		32.42	
MgO	.22	.51	.42		.45	
CO_2	.63	5.08	2.03		1.67	Mg SO_4 .61
SO_3	45.95	34.98	37.49		44.18	
H_2O	19.54	16.59	16.75	20.66	19.4	20.2
Al_2O_3	.23	.6	.99	1.98	.24	.6
Fe_2O_3						
$CaCO_3$				7.25		
$MgCO_3$				1.12		
$CaSO_4$				58.25		75.66
	99.76	98.63	98.95	98.04	100.53	

1 Pyramid of Cheops, exterior. Thorpe. Dictionary of Applied Chemistry. 1:468

2 Pyramid of Cheops, interior. Thorpe. Dictionary of Applied Chemistry. 1:468

3 Wienrode. Analyst, Jungst

4 Osterode. " Hampe

5 Albay, Philippines. " Trobe

6 Nova Scotia. Rep't Ct. Agric. Exp. Sta. 1883

7 " " "

8 " " "

9 " " "

10 Union Springs N. Y. " 1884

11 Fayetteville N. Y. Rep't Ct. Agric. Exp. Sta. 1883

12 " " "

13 Wheatland N. Y.

14 Cottons N. Y.

15 Ottawa county, O. Geol. of Ohio. 1888. 6:696–702

16 Fort Dodge Ia. Geol. Sur. Ia. 3:291

17 ——— Mich. Analyst, George H. Ellis, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 143

18 Wheatland N. Y. Anal. furnished by Iroquois Portland Cement Co.

19 " 2d bed. Anal. furnished by Consolidated Wheatland Plaster Co.

20 ....

21 Coalinga Cal. Univ. of Cal. Exp. Sta. 1891–92

22 Nevada Gypsum and Fertilizing Co. Univ. of Cal. Exp. Sta. 1891–92

23 Bakersfield mine, Cal. Univ. of Cal. Exp. Sta. 1891–92

24 Southern California " "

25 San Francisco Cal. " "

26 Los Angeles Cal. " "

27 Fowler mine, Blue Rapids Kan. Analyst, Edward Bartow, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 145

28 Great Western, Blue Rapids Kan. Analyst, Edward Bartow, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 145

29 Winter's mine, Blue Rapids Kan. Analyst, Edward Bartow, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 145

30 Dillon Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 146

31 Four miles south of Dillon Kan. Analysts, Bailey & Franklin, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 146

32 Hope Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 147

33 Medicine Lodge Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 147

34 Solomon Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 148

35 Marlow, I. T. Analysts, Bailey & Stafford, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 149

36 Dillon Kan. Analysts, Bailey & Whitten, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 149

37 Rhoades Kan. Analysts, Paul Wilkinson, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 150

38 Mulvane Kan. Analysts, Bailey & McFarland, Univ. Geol. Sur. Kan. v. 5, Gypsum, p. 155

39 Lake Tank, New South Wales. Liversidge, A. Minerals of New South Wales, p. 164

LIST OF FIRMS AND INDIVIDUALS THAT MINE AND MANUFACTURE NEW YORK GYPSUM

Clockville, J. A. Mason jr.

Cottons, R. D. Buttons

Fayetteville, C. A. Snook, National Plaster Co., office at Syracuse, F. M. Severance

Garbutts, Lycoming Calcining Co.

Hobokenville, Irving Tuttle

Indian Falls, Standard Plaster Co.

Jamesville, Robert Dunlop, Simon Reals, E. B. Alvord & Co.

Manlius, James Behan *Est.*

Oakfield, Oakfield Plaster Manufacturing Co., U. S. Gypsum Co.

Perryville, Cyrus Worlock, Mrs Hattie C. Hodge

Phelps, A. D. Miller

Port Gibson, Ezra Grinnell

Union Springs, Cayuga Plaster Co.

Valley Mills, W. H. Osborne & Co.

Victor, Theodore Conover

Wheatland, Wheatland Land Plaster Co.

It was the intention, when this publication was started, to include a description of the mills calcining and using foreign gypsum. This, however, has been found to be impracticable, but a list of those who use this material is appended.

LIST OF MANUFACTURERS IN NEW YORK STATE WHO USE GYPSUM FROM OUTSIDE OF THIS STATE

Adamant Plaster Co.	Syracuse and New York city
American Hard Wall Plaster Co.	Utica
Higginson Mfg. Co.	Newburg
J. B. King & Co.	New York city
V. C. & C. B. King	New York city
Paragon Plaster Co.	Buffalo and Syracuse
Rock Plaster Co.	New York city
Schenectady Wall Plaster Co.	Schenectady

BIBLIOGRAPHY

The following is a list of some of the most important articles treating on gypsum in general and New York gypsum in particular. The list might be greatly extended so as to embrace those describing other localities, but it is believed that the reader will find every important phase of the technology and manufacture of gypsum taken up by the authors noted below.

Solubility of gypsum

Hulett, George A. and Allen, Lucius E. The Solubility of Gypsum. Jour. Am. Chem. Soc. July 1902. No. 7, v. 24

McCaleb. Am. Chem. Jour. 1889. 2:30

Marignac. Annales de chimie. Ser. 5. 1:274

Rose, H. Poggendorff Annalen. 93:606

Storer. Dictionary of Solubilities

New York gypsum deposits

Clarke, William C. Gypsum Industry of New York State. New York State Mus. Bul. 11. 1893. p. 70–84

Merrill, F. J. H. Gypsum Deposits of New York. New York State Mus. Bul. 15. 1895

Parsons, Arthur L. Recent Developments in the Gypsum Industry of New York State. 20th Rep't State Geologist. Alb. 1900

Williams, S. G. Geological Relations of the Gypsum Deposits in Cayuga County, N. Y. Am. Jour. Sci. September 1885. v. 130

Technology of gypsum

Grimsley, G. P. Technology of Gypsum. Mineral Industry, v. 7

Grimsley, G. P. and Bailey, E. H. S. Special Report on Gypsum and Gypsum Cement Plasters of Kansas. Univ. Geol. Sur. Kan. Topeka 1899

Knapp, F. Chemical Technology. Am. ed. Phil. 1849. 2:400–12

Le Chatelier, Louis. On the Dehydration of Gypsum Stone and the Two Compounds Formed. Académie des sciences. Comptes rendus. 1883

Payen. Traité du chimie industrielle. 1830

Redgrave. Calcareous Cements, their Nature and Uses. 1895

Thorpe. A Dictionary of Applied Chemistry, article on cements. v. 1

Wagner, Rudolph. Chemische Technologie

Wilkinson, Paul. Technology of Cement Plaster. Am. Inst. Min. Eng. Trans. July 1897

Origin of gypsum

Dieulafait. Produits, successifs, abandonnés par les eaux de la mer. Annales de chimie. Ser. 5. 1878. 14:381

Hunt, T. Sterry. Origin of Gypsum, Chemical and Geological Essays, ch. 8

———. Origin of the Gypsum of Plaister Cove. Quar. Jour. Geol. Soc. 5:339

Ochsenius. On Composition of Sea Water. Chem. Zeitung. 1887. v. 2, no. 56, *et seq.*

Gypsum as fertilizer

Davy, *Sir* **H.** Agricultural Chemistry

Johnson, C. W. An account of Gypsum as a Manure to the Artificial Grasses. Royal Agric. Soc. England. Proc. 1841. v. 2

Liebig. Chemistry of Agriculture

Stockhardt. A Familiar Exposition of the Chemistry of Agriculture. 1855

Storer. Chemistry of Agriculture. 1887. 1:206, 216

ABRASIVES OF NEW YORK STATE

BY HARRY C. MAGNUS

In the following paper the writer has endeavored to present in collected form the substance of all published matter which has for its subject any of the various abrasive materials found within the limits of New York State. A large amount of material has been obtained from previous publications of the State Museum. The *American Journal of Science and Arts, the Scientific American, Mineral Industry, Transactions of the American Institute of Mining Engineers* and other scientific and technical publications have also been fruitful sources of reference. Information concerning the development of the several industries within recent years has been furnished to the writer by the individuals and companies engaged in the mining and preparation of the various materials; and to these, notably, Herman Behr & Co., Mr F. C. Hooper of North Creek, Warren co., H. H. Barton & Sons Co., the Norton Emery Wheel Co., the Standard Emery Wheel Co., the Pike Manufacturing Co., Mr J. S. Van Etten and the Carborundum Co., he wishes to express his indebtedness for much valuable assistance.

A list of references on the abrasive materials of New York is appended to this paper under the title of Bibliography.

Garnet

Garnet, though one of the most abundant rock-forming minerals, is found in only a few localities of proper character to be of value as an abrasive. It is mined or quarried in New York State on the southeastern border of the Adirondack region, in Warren and Essex counties, where it appears to be of the common variety, "almandite." In Delaware county, Pa., it occurs near Chelsea in small crystals thickly disseminated through a quartzose gneiss. This deposit about the year 1895

yielded 1000 tons annually.[1] There is also a deposit of garnet near Chester Pa. In North Carolina large deposits of garnet were worked in connection with the deposits of corundum. These yielded the first American garnet, but were abandoned as of inferior quality when the New York State material appeared in the market. Other deposits are said to occur in Georgia and Alaska, but no definite information can be obtained about them. Maine has supplied a very limited amount of inferior material, and Connecticut for a time competed in the production of garnet for sandpaper used in the shoe trade. In 1898 Connecticut together with Pennsylvania furnished 1200 tons of garnet, but New York garnet has gained great favor in the market owing to its superior hardness.[2]

In New York, garnet is found, in Warren county, in the valley of the upper Hudson river and in Essex county on the borders of the Adirondack region. These deposits were described by Mr Verplanck Colvin in his report on the New York State Land Survey for 1896 as follows:[3]

Garnet peak is the next summit northwesterly from the Black Eagle, or northerly from Crow mountain, and its steep, gray ledges are very noticeable on the easterly side of the Blue mountain road at the summit, where the land begins to descend northerly. In this vicinity are several mines of the mineral popularly styled "pocket garnet," the pockets being merely large crystals, sometimes quite regular in form, but often in large amorphous masses. In the adjacent part of the fourteenth township is a mine, and a mill at which the mineral is separated.

He describes the deposit on Gore mountain more particularly.

These mines are, perhaps, the most remarkable of their kind known; certainly the most notable in this section of the country. A zone perhaps 100 feet in thickness, richly charged with the mineral, here extends along the northerly face of the mountain, at an elevation of about 2800 to 2900 feet above the sea. The

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[1] N. Y. State Mus. Bul. 15. p. 553.
Min. Ind. 1896. v. 5.

[2] Min. Ind. 1897. 6:21.

[3] Report of Superintendent of State Land Survey. 1896. p. 133–35.

country rock on either side is a hard gneiss, containing very little mica, though broken crystals of what appeared to be biotite or phlogopite were met with.

The remarkable feature of this deposit consists in the innumerable crystals of the so called pocket garnet with which it is filled. These crystals are almost as abundant as cobblestones in a bank of glacial drift; not by any means perfect crystals, but coarse, irregular clusters, of which the matrix may be estimated to contain from 10 to 15%, and in places 20% of its volume, all of deep red, irregular masses of mineral. They are found of all sizes, from small bits up to enormous pockets, a foot or more in diameter, and it is claimed that crystals of 3000 pounds in weight have been taken from this mine. These large crystals, however, are not permanently knitted together, for the decomposition of the enclosing rock seems to have penetrated them also, so that frequently the broken fragments can be picked out easily with a stick, knife or trowel, and fall into the hands of the collector as dull, ruby-colored, disintegrated masses. In some cases huge crystals crumble so easily that a shovel full of broken garnet can be taken from a single pocket in the rocks.

The Warren county garnet[1] occurs in a formation of crystalline limestone which appears to form the bed rock in the vicinity of Minerva and in the gneissoid rocks which adjoin it. Prof. J. F. Kemp finds, from specimens furnished him from the North River Garnet Co.'s deposits, that the immediate associate of the garnet there is a rock containing 60% hornblende and a very basic triclinic feldspar, probably anorthite. The following is his description of the geology of these deposits as printed in the *Mineral Industry.*

The wall rock contains a large percentage of quartz, fully 50%. With it are oligoclase and small amounts of orthoclase, microperthitic feldspar, hornblende, green augite and considerable pyrrhotite and zircon. This is a not uncommon rock in this section of the Adirondacks. Its granulation is due to pressure, and all the above minerals are shattered and strained by mountain-making upheavals. It was probably a rather feldspathic sediment originally that became metamorphosed to a gneiss, but it may have been a granite or similar rock now crushed and granulated. The garnet bed must be either a metamorphosed and originally impure limestone, which is most probable, or a

[1] N. Y. State Mus. Bul. 15. p. 553.

very basic eruptive rock changed by metamorphism to its present state.[1]

The garnet occurs in masses of varying size, from pieces the size of an egg to masses having a diameter of 20 feet and more. The various qualities are distinguished commercially as massive garnet, shell garnet and pocket garnet. The massive garnet is very impure from the presence of other minerals. The shell garnet is the almost pure material and is the most desirable for industrial purposes. The pocket garnet occurs in small accumulations, incipient crystals, in the gneiss.[2] This Adirondack material, though of the common variety almandite, is however extremely hard, its hardness being 8., which is from 1.5 to .5 harder than the general hardness of this variety. Its popularity among garnet paper manufacturers is due to this extra hardness and a tendency to cleave more easily than other occurrences of the same variety.

Methods of extraction and preparation

The garnet is mined entirely by open cut work and was formerly picked out by hand. By this process only the very richest beds could be worked, and the decomposed surface portions usually determined the extent to which the deposit could be developed. The best garnet in the solid rock was left and covered over by the debris from the working of the surface material. In 1899 a new mechanical process was established by Mr F. C. Hooper, of the North River Garnet Co. of North River, Warren co., by which the rock was broken down by steam drills, crushed and the garnet concentrated by gravity. By this method, garnet, 95% pure, is obtained, an increase in purity of from 25% to 45% over the old method of hand-picking. This degree of concentration is remarkable when the difference in specific gravity between the minerals to be separated is less than .5. Specimens of pure garnet and pure hornblende from the North River Garnet Co.'s mines gave specific gravities of 3.2

[1] Min. Ind. 1898. 6:20.

[2] N. Y. State Mus. Bul. 15. 1895. p. 553.

and 3.7 respectively. Mr Hooper has not made public the details of his separation process, but, by its means, the present plant is capable of crushing and separating 150 tons of ore per day (1903).

The entire output of the mines of this company is sold to Herman Behr & Co., of New York city, Boston and Chicago, who have extensive plants for the preparation from the raw material of the various forms of garnet paper, etc.

H. H. Barton & Sons Co., of Philadelphia Pa., work mines on Gore mountain in close proximity to the mines of the North River Garnet Co. Here the garnet is found in pockets averaging from 5 to 10 inches in diameter, occurring near the summit of the mountain in a decomposed hornblende rock. The mines are all open cuts, workable material being found almost on the surface.

There is at present no plant connected with these mines. The product is all hand-picked. Further development of the property will probably render the erection of a mechanical separation plant a necessity.

According to figures furnished by H. H. Barton & Sons Co. the Gore mountain mines produced during 1902 about 1000 net tons.

The following table shows the production of garnet in New York State in recent years.

Year	Short tons	Value per ton	
1893	1475		
1894	294		
1895			
1896			
1897	1050	$40[1]	
1898	1686	28.77[2]	
1899	1656	28.33[2]	
1900	2508	28.35[2]	$40[1]
1901	2500	28.25[2]	

[1] Price of Adirondack material.

[2] This is the average price per ton for garnet from all localities in the United States. North River garnet brought a slightly higher price.

In 1899 some garnet was imported from Africa, but on practical test it was found to be inferior to the New York State material, and its importation was discontinued.

Uses of garnet

The ready cleavage of garnet makes it a most valuable abrasive in the leather and wood industries. Quartz and emery rapidly become dull, but the garnet, owing to its brittleness along cleavage planes, continually presents sharp cutting edges. The various grades of garnet paper are known commercially as sandpaper, garnet paper or shoe paper. It is of some use in the polishing and grinding of brass, but for other metals emery is considered better. A manufacturer of paper mill machinery has used garnet in place of emery for grinding joints of ironwork where the mineral is confined between two surfaces. In comparison with emery, only one half of the weight was required, and a perfect joint was secured in half the time.[1]

Garnet has been mixed with emery and corundum in wheels, but the combination was not successful.

Emery

Emery occurs within the United States at three localities along the Atlantic seaboard and at one or two places in the middle west. The eastern deposits are the most fully developed, and of these that at Chester Mass. is the most prominent. Emery is found in New York about 4 miles southeast of Peekskill and 2 to 3 miles east of the Hudson river. It occurs in a series of igneous rocks which have been intruded into the metamorphosed sediments of this region. These intrusions cover an area of over 15 square miles, lying mostly within the town of Cortlandt, whence they derive the name of the "Cortlandt series" given to them by J. D. Dana in 1880.[2] This series consists mainly of rocks of the gabbro family. Norites, diorites and peridotites are by far the most abundant. The principal associate of the emery deposits is a norite.

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[1] Min. Ind. 9:299.

[2] Am. Jour. Sci. Ser. 3. 1880. 20:199.

Throughout the region covered by these intrusives are deposits of aluminous titaniferous magnetite. On the eastern and southeastern borders this ore becomes very aluminous with a proportionate decrease in the amount of iron, and in these portions it is mined for abrasive purposes.

Prof. G. H. Williams, in a paper on the norites of the "Cortlandt series,"[1] published the results of a very careful study of these deposits. It was his opinion, after extended microscopic inspection of this material, that it consisted chiefly of an iron-magnesian spinel (hercynite), and that there was a striking similarity between these ores and certain magnetite deposits at Routivara, Sweden. Prof. J. F. Kemp has remarked a like similarity between these deposits and certain of the emery deposits in North Carolina. The latter are not, however, titaniferous to any marked extent.[2]

The deposits according to Professor Williams are segregations of the basic minerals of the norite, the purest of the emery being found to contain all the component minerals of the norite.[3]

An inspection of a series of thin sections of material from these deposits[4] under the microscope showed that they consisted of hercynite, magnetite and corundum of a very light color. Of these minerals the hercynite was by far the most abundant, forming in some cases over 50% of the material in the slide. The corundum occurs in small crystals containing medial inclusions of what appeared to be magnetite. Magnetite in grains showing a crystalline outline is also included in the hercynite.

The proportions of corundum and hercynite are very variable. In some specimens the corundum will make up over 50% of the slide, while in others the material is almost 100% hercynite.

The hercynite is inferior in hardness to the corundum, corundum being 9 in the scale of hardness, while hercynite is

[1] Am. Jour. Sci. Ser. 3. 1887. 33:194.

[2] Kemp, J. F. School of Mines Quarterly. July 1899. p. 345.

[3] Am. Jour. Sci. Ser. 3. 33:196.

[4] A series of slides of this material was furnished the author by the kindness of Prof. J. F. Kemp, of Columbia University.

about 8. This softness is in some measure compensated by the more ready cleavage of the hercynite, which causes it always to present fresh, sharp cutting edges. It is claimed by manufacturers of emery products that this Westchester material is extremely serviceable when made into wheels[1] with a vitreous bond, excelling the emery from other localities in this particular form of wheel.

The deposits of emery occur irregularly and vary very considerably in size. Some openings have yielded over 100 tons without showing signs of exhaustion, while others yield a scant 20 tons or less. The mines are located on the outcrops of the ore, which are often discovered by the turning up of fragments while plowing in the fields. They are all open cuts, varying in width and depth with the size of the ore body. The ore is blasted out by light charges of explosives and is broken up and roughly cobbed to remove the greater part of the impurities before shipping to the mill.

In the early history of these mines the ore was smelted in the blast furnaces of the neighborhood for the iron it contained.

There it proved so refractory that this method of treatment was soon abandoned. Dr J. P. Kimball in 1874 wrote a paper advocating the use of this ore as a lining for puddling furnaces and as a source of multibasic slags.[2] It was never used in this connection to any great extent. In this paper Dr Kimball published four analyses of the Peekskill ore, which were made for him by C. F. Chandler and F. A. Cairns. These, together with analyses of the ore by T. M. Drown and T. Egleston and three analyses of the associated rocks published by J. F. Kemp in his *Handbook of the Rocks*, are reprinted in the accompanying table.

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[1] Min. Ind. 1901. 10:17.

[2] American Chemist. 1874. 4:321.

Table of analyses of ore and associated rocks

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SiO_2	1.13	1.04	2.88	.51	.32	6.82	13.97	....	....	....	....	....	....	....	54.72	55.34	47.41
Al_2O_3	45.58	36.46	34.47	39.36	41.28	45.29	20.95	31.93	40.77	37.78	37.43	36.49	41.66	46.53	17.79	16.37	6.39
FeO	21.14	18.49	17.92	45.86	....	....	....	....	....	....	....	....	....	....	6.03	7.54	4.80
Fe_2O_3	25.86	28.21	28.7	....	....	....	....	18.19	18.37	24.35	21.17	21.36	23.71	32.31	2.08	.77	7.06
CaO	....	....	....	.47	....	....	....	....	....	....	....	....	....	....	6.84	7.51	14.32
MgO	....	....	....	7.18	....	....	....	7.41	6.73	7.92	7.20	8.39	7.91	9.43	5.85	5.05	15.34
MnO	....	....	....	.55	....	....	....	....	....	....	....	....	....	....	....	....	....
Cr_2O_3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
TiO_2	3.88	3.52	4.41	2.41	3.9	1.9	4.15	1.12	1.08	.62	.65	.67	.54	.51	....	....	....
P_2O_5	.16	.09	.16	.22	....	....	....	tr	tr	tr	tr	tr	tr	tr	....	....	....
Fe	34.54	34.13	34.03	34.44	35.82	29.16	40.32	....	....	....	....	....	....	....	....	....	....
H_2O	....	....	....	1.18	....	....	....	....	....	....	....	....	....	....	....	....	....
Silicious residue	....	....	....	....	....	....	....	6.42	1.04	11.19	13.14	10.08	11.48	2.42	....	....	....
Sulfur	....	....	....	....	....	....	....	.04	.04	.02	.02	.02	.01	.01	....	....	....
Fe_3O_4	....	....	....	....	....	....	....	34.20	32.01	17.37	19.81	22.77	14.76	8.98	....	....	....

1, 2 and 3 from Am. Inst. Min. Eng. Trans. 1881. 9: 19. T. M. Drown analyst.
4, 5, 6 and 7 from Am. Chemist. 1874. 4: 321. C. F. Chandler and F. A. Cairns, analysts. No. 4 had also FeS_2 2.63.
8 to 14 inc. from Am. Jour. Sci. March 1887. p.197. T. Egleston, analyst.
15, 16, 17 from Handbook of Rocks. J. F. Kemp, p.49. Have also (15) Na_2O 3.02 and K_2O 3.01. Gabbro, (16) " 5.09 " " .96. Norite, (17) " .69 " " .20. Peridotite — of Cortlandt series

In a contribution to the *American Journal of Science* on the limestone belts of Westchester county, Prof. J. D. Dana[1] in 1880 made mention of the presence of corundum in iron ores from this locality. Though he did not arrive at a true understanding of the mineralogic composition of these deposits owing to his error in mistaking for chlorite, what Professor Williams later proved to be hercynite, he drew attention to the abrasive quality of the material. A short time afterward an emery mill was established at Peekskill by the New York Emery Co., which for a time ran on the ore from the immediate vicinity, but it gradually abandoned the Peekskill ore, till in 1887 it was run almost exclusively on emery from Asia Minor. It was finally closed up and has not been reopened.

At the present time two companies are engaged in mining this ore, the Tanite Co. of Stroudsburg Pa., which controls most of the product, and the Ashland Emery and Corundum Co., formed[2] in 1900 by a combination of several of the leading emery mills in the country. The output of this region was estimated at over 1000 tons for 1896.[3] An estimate of the average annual output made in 1898 was from 500 to 700 tons per annum.[4] From the rapid growth of industries making use of the finished products and recent developments in methods of manufacture, a large increase in the output is to be expected.

Mill treatment

The final cleaning and grading of the roughly cobbed material received from the mines is carried on by several different methods which vary with the character of the matrix.

The Norton Emery Wheel Co. of Worcester Mass. treat the rough material by the following process, a description of which was furnished to the writer by Mr Charles L. Allen, manager of the company. The lumps are first crushed in a large stone

[1] Am. Jour. Sci. Ser. 3. 20:9, 199.
[2] Min. Ind. 1901. 10:18.
[3] Min. Ind. 1900. 9:16.
[4] Am. Inst. Min. Eng. Trans. 28:567.

crusher which reduces them to smaller pieces, they then pass through a smaller crusher; and from there they pass successively over six sets of rolls. The idea is to crush as little as possible each time, so that the minimum quantity of fine powders is obtained, as the manufacture of wheels demands a large proportion of the coarser grains. From the rolls the material is passed through washers, then driers, and from the driers it goes to the graders. Here it is screened, the various powders resulting from the screening being known by the number of meshes to the square inch in the sieve through which they have passed. The coarsest used is 14 and the finest 180. Between these two limits the grades run 16, 20, 24, 30, 36, 46, 60, and then by tens up to 180.

In the Sapphire mills of the Hampden Emery Co. of Georgia and North Carolina, where the material handled is embedded in a soft chloritic matrix, the material on coming from the mine is hoed with wooden hoes in inclined troughs filled with running water. It is then crushed and passed over a 14 mesh sieve. The portion which passes through the sieve is then treated by what is known as the muller process. The crushed and screened material is placed in a circular trough and is there agitated by two heavy wooden rollers each 5 feet high. These rollers are attached to a revolving shaft which rises through a platform in the center of the trough. This trough is kept full of water. The cleansing of the material is effected by the rubbing of the hard grains of emery one against the other, thus wearing off the softer matrix, which, being light, is carried out by the water flowing over the central platform, the heavy emery remaining in the bottom of the trough. After being subjected to this muller process for from three to five hours, the material left in the bottom of the trough is removed and dried by one of many hot air processes. In the Sapphire mills it is dropped down a chimney on a soapstone slide a distance of about 20 feet. It is then crushed in rolls and sorted into various grades by screening.

The finest of the numerous grades are again rewashed and sorted by what is known as the elutriation process. The powders are suspended in water and forced through a set of tanks or cylinders, each 3 feet high and varying from 3 inches to 40 inches in diameter. That portion of the material that can no longer be supported by the decreasing strength of the current as it passes from the smallest to the largest tank, settles to the bottom and is afterward drawn off. Any impurities that may have passed through the first cleaning process pass out with the surplus water. The powders thus obtained are dried and are then ready for market.[1]

In this condition the emery is purchased by the manufacturers of emery products, who make it up in wheels, stones, emery paper, emery cloth, etc.

The wheels are made by binding the grains with some cementing material. Celluloid, rubber, silicious and vitreous bonds are used, each being specially adapted to certain classes of work. The required amounts of emery and bond are carefully measured out, thoroughly mixed, tamped into a mold and put in a kiln. The temperature of the kiln varies from about 300° F. in the case of vitreous bond to 150° F. when the least refractory bonds are used.

A bond composed of sodium silicate and zinc oxid is used by the Standard Emery Wheel Co. of Easton Pa., which till 1903 was located in Albany N. Y. This bond set at a very low temperature, no fusion being required.

On removal from the kiln, the wheels are trued and shaped in a lathe, the cutting of the wheel being accomplished by the use of black diamond (carbonado).

Much of the success of an emery wheel depends on the selection of a bond suitable to the work to be accomplished. It is therefore the present practice, when ordering emery wheels, to specify the work which is to be accomplished by the wheel,

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[1]The above description is condensed from an article by C. N. Jenks on corundum. Min. Ind. 1896. 5:26.

leaving the manufacturer to combine his materials to suit that particular case.

Large amounts of the various grades of emery are used in the manufacture of emery paper and emery cloth, in which form it is used in the process of tool manufacturing and in almost all metal industries. Quantities of powder are sold to the same manufacturers for use in the grinding of joints and polishing metal.

In 1894, 250 tons of powder were consumed in the glass beveling industry. Emery paper and cloth are used in large quantities by shoe manufacturers, woodworkers and brass founders; but in these industries it finds a strong competitor in garnet products.

During the year 1894, Mr C. N. Jenks, of Asheville N. C., made a series of very careful tests on the cutting properties of various abrasive materials. The tests were made on wheels of uniform size which were prepared under his personal supervision. The raw materials from which these wheels were made were purchased in the open market. They were subjected to tests carefully planned and watched, which were as nearly equal for each wheel as it was possible to make them. The following list gives the materials tested in the order of their cutting quality.[1]

1 Diamond
2 N. C., Jackson county, corundum
3 N. C. and Ga. corundum, known as "Standard"
4 Chester Mass. emery
5 Best Turkish emery (Abbotstone)
6 Bengal India emery
7 Naxos emery
8 Peekskill N. Y. emery
9 Garnet. N. C., in chloritic matrix
10 Carborundum
11 Crushed steel
12 Best flint quartz and ordinary garnet
13 Common quartz and burstone, flint, sand, etc.

[1] Scientific American, Supplement, Dec. 8, 1894. No. 988.

Diatomaceous earth

The deposits of diatomaceous earth occurring within the limits of this State are at present of but little economic importance, the majority of this material being supplied from localities in the west. The following is taken from a description of these deposits published by F. J. H. Merrill in bulletin no. 15 of the New York State Museum.[1]

Diatomaceous earth occurs in New York State at White Lead lake in Wilmurt, Herkimer co., and on the property of Dr Oliver Jones at Cold Spring Harbor L. I. This material consists of hydrated silica. The deposits are accumulations of the silicious skeletons of minute plants known as diatoms. They accumulate in the bottom of ponds and lakes and are of recent age as well as Tertiary or Cretaceous. Though living diatoms are abundant in all the waters of the State, deposits have been found only at the above mentioned localities.

The deposit at White Lead lake is owned by Mr J. W. Grosvenor and is the only one worked at present. The material is dug from the bottom of the lake, washed and run through strainers into settling vats, where it stands for 24 hours. The water is then drawn off and the residue shoveled into a press. It is here pressed into blocks 4 feet square and 4 inches thick, which are cut into cakes 1 foot square and piled under sheds to dry. The following analysis of the White Lead lake material was made by Mr Gideon E. Moore of New York.[2]

Water and volatile matter	12.12
SiO_2	86.515
Al_2O_3	.449
Fe_2O_3	.374
CaO	.12
Undetermined	.422
	100

[1] N. Y. State Mus. Bul. 15 :555.
[2] Bul. 15 :556.

While constructing the road bed of the Malone & Mohawk Railroad, numerous deposits of diatomaceous remains were discovered in the small lakes and ponds of the region adjacent to the line of the road. A careful investigation of the largest of these was made during 1893 and 1894 by Mr D. C. Wood, engineer in charge of Dr W. S. Webb's Nahasane park. The results of his investigations were published by Mr C. F. Cox in a paper read before the New York Academy of Science in 1894.[1] The survey was made with the idea of the development of these deposits on an economic basis, and Mr Wood reported eight ponds as containing these remains in sufficient quantity to be worked at a probable profit. The material in these eight ponds was exceedingly clean and covered from 2½ to 3 acres in each pond, ranging in depth from 1 foot to 12 feet.

In specimens of the material from the various localities discovered by Mr Wood, Mr Cox found 16 genera and 40 species of diatoms, the most abundant being Stauroneis, Cymbella, Eutonia, Navicula, Surirella, Melosira, Gomphomena and Epithemia.

In a previous paper[2] Mr Cox discusses the deposit at White Lead lake near Hinckley in Herkimer county. Here he found the same genera as in the other deposits. The remains of the genus Surirella were not so numerous as in the deposits to the north.

Mr Cox inferred from the presence of both fixed and free swimming forms that the deposits were not entirely lacustrine in their origin, the inflowing streams having contributed a portion of the deposit represented by the skeletons of the fixed forms, Melosira, Gomphomena, Epithemia etc.

Millstones

Material suitable for millstones is found in the Shawangunk grit (Oneida conglomerate) of Ulster county, N. Y., in Lancaster county, Pa., where it is called Cocalico stone, and in Montgomery county, Va., where it is known as Brush mountain stone. The New York material is sold under the name of Esopus stone. The

[1] N. Y. Acad. Sci. Trans. 1894. 13:98.

[2] N. Y. Acad. Sci. Trans. 1893. 12:219.

Shawangunk grit from which it is quarried is a light gray quartz conglomerate. The quartz pebbles are usually of a milky color and vary in size from a diameter of $\frac{1}{16}$ inch to a diameter of $1\frac{1}{2}$ inches. The matrix is a gritty silicious paste. These grits begin at High Falls and extend with increasing hight into Pennsylvania. The beds are of unequal thickness but of the same general character throughout the county.

The method of quarrying is very simple. A large block of stone is separated by means of its natural lines of bedding and jointing. It is then roughly dressed to shape by wedges, holes being drilled into which the wedges are driven. A final tool dressing fits the stone for market.[1]

These stones vary in size and also in price. For milling, stones are furnished from 15 inches to 7 feet in diameter. The larger stones or "Chasers" are used in grinding and crushing quartz, feldspar, etc. The smaller stones are used principally in portable mills for grinding cement, plaster, paint, and corn. Blocks of this material, 12 by 10 by 12 inches, are used in paving the chaser floors. In 1893 the large stones 7 feet in diameter brought prices between $50 and $100. The smaller stones sold from $5 to $15 and upwards. The introduction and increasing adoption of the roller process in flour mills and other industries caused a great decrease in the total annual value of this industry,[2] but recently the output has begun to expand.

To Mr James S. Van Etten the writer is indebted for the subjoined list of producers of Esopus stone for 1903.

Miles Decker	Granite N. Y.
James S. Van Etten	Granite N. Y.
Ambrose Van Etten	Granite N. Y.
W. H. Rose	Accord N. Y.
James Jonsbury	Kerhonkson N. Y.
Joseph Davis	Kerhonkson N. Y.

[1] N. Y. State Mus. Rep't State Geologist. 1893. p. 393–94.

[2] Rep't N. Y. State Geologist. 1893. p. 393–94.

Alundum and carborundum

Alundum

In 1902 the Norton Emery Wheel Co. of Worcester Mass., established a plant at Niagara Falls for the production of artificial corundum from the mineral bauxite. This artificial product is called "alundum" by the manufacturers, who have not as yet made public the process of manufacture.

From figures kindly furnished by the Norton Emery Wheel Co., the following table showing the relative amounts of pure crystalline corundum in the natural ore and manufactured product, has been prepared.

AVERAGE ANALYSES OF CORUNDUM

	Al_2O_3	Fe_2O_3	S_1O_2	Loss
Best Turkish emery	67.89%	26.72%	5.37%	
" Naxos emery	69.13%	25.46%	2.57%	2.19%
" India emery	90.06%	4.25%	5.17%	.77%
Alundum	97.99%	1.50%	.95%	

At present the entire output of the factory at Niagara Falls is consumed by the home company. It is expected by the management that it will soon be in condition to place large quantities on the market. Large demand for this product has already been made, and it bids fair to prove a powerful competitor of carborundum.

Carborundum

Process of manufacture and refinement

Carborundum is a carbid of silicon, in its crude state, a lustrous irridescent mass of tabular hexagonal crystals. Its chemical formula is CSi, and it closely approaches the diamond in hardness. Absolutely pure carborundum is white. In commercial manufacture the crystals are produced in many colors and shades, partly as a result of impurities, and partly owing to surface oxidation. The prevailing colors are green, black and blue.

Sand, coke, sawdust and salt are the raw materials from which carborundum is made. In early experiments clay was used instead

of sand, but it was soon discovered that the silica of the clay was the only portion consumed in the process of manufacture, and a good glass sand was substituted. The process of manufacture as described by Mr Francis A. Fitzgerald in a lecture delivered before the Franklin Institute on Dec. 11, 1896, is as follows:[1]

The crude materials for the manufacture of carborundum, viz, sand, coke, sawdust and salt, are received in the stock building. These are ready for immediate use, with the exception of the coke, which must be reduced to kernels of a certain size to be used as "core" and ground to a fine powder to be used in making the mixture or charge for the furnaces. To effect this, the coke is first passed through a grinder, which breaks it up into small pieces, and is then conveyed to the upper part of the building, where it is passed successively through two cylindrical screens. The first of these removes all particles of coke which are too small to form the core, while the second allows kernels of the requisite size to pass through its meshes and fall into the core bin, conveniently situated as regards the other constituents of the mixture. Below this bin are scales on which the sand, coke, sawdust and salt are weighed out in proper proportions, and then conveyed by an elevator to a mechanical mixer, from which the mixture, ready for use, is emptied into a bin. The arrangement of the machinery connected with all this work is such that it can be attended to with ease by two men.

The furnace room is built to accommodate 10 furnaces, though at present there are but five. The furnaces are built of brick and have the form of an oblong box, the internal dimensions being, approximately, 16 feet in length, 5 feet in width and 5 feet in depth. The ends are built up very solidly, with a thickness of about 2 feet. In the center of either end are the terminals, consisting of 60 carbon rods 30 inches long and 3 inches in diameter. The outer ends of the carbons are inclosed in a square iron frame, to which is screwed a stout plate, bored with 60 holes corresponding to the ends of the carbon. Through each of these holes is passed a short piece of ⅜ inch copper rod, fitting tightly in a hole drilled in the carbon. Finally, all the free space between the inside of the plate and the ends of the carbons is tightly packed with graphite. Each plate is provided with four projections, to which the cables conveying the current may be bolted. These ends are the only permanent parts of the furnace; the remainder, which we shall now consider, is built up every time the furnace is operated.

[1] From notes of lecture published in pamphlet form by the Carborundum Co.

The side walls of the furnace are first built up to a hight of about 4 feet. Pieces of sheet iron are then placed at a distance of about 4 inches from the inner ends of the carbon terminals in such a way as to keep the mixture from coming in contact with the latter. The mixture is then thrown into the furnace till it is rather more than half full. A semicircular trench, having a radius of 10½ inches and extending from end to end of the furnace, is now formed, the bottom of the trench being a little above the level of the bottom row of carbons. Into this trench is introduced the core, which has been carefully weighed, so that the amount required to make the core of the right size is used. One of the furnaces at Niagara Falls requires about 1100 pounds of "new core," that is to say, core which has come directly from the bins, or about 850 pounds of "old core," or core which has already been used in the furnace. The reason for this difference in weight will appear later. All the core having been emptied into the trench, the top is rounded off neatly by hand, so that, when finished, we have a solid cylinder 21 inches in diameter and about 14 feet long, composed of small pieces of coke and extending from the sheet iron plate at either end of the furnace.

The next operation is to make the connections between the core and the terminals. This is done by packing finely ground coke into the spaces between the ends of the carbons and the pieces of sheet iron, after which the walls are built up to a hight of about 5 feet, the pieces of sheet iron removed, and more mixture thrown in and heaped up to a hight of about 8 feet.

All that is required now to make carborundum is the electric current.

After the circuit has been closed in the transformer room, no apparent change occurs in the furnace for about half an hour. Then a peculiar odor is perceived, due to escaping gases, and, when a lighted match is held near the furnace walls, the gas ignites with a slight explosion. When the current has been on for three or four hours, the side walls and top of the furnace are completely enveloped by the lambent blue flame of carbon monoxid gas, formed by the combination of the carbon of the coke with the oxygen of the sand. During the run of a single furnace 5½ tons of this gas are given off. At the end of four or five hours the top of the furnace begins to subside gradually, and fissures form along the surface, from which pour out the yellow vapors of sodium. Occasionally the mixture on the top of the furnace is not sufficiently porous to allow the rapid escape of the gases. The result is that the latter accumulate until the pressure is so great that, at some weak point in the mixture above, a path is forced open and the gases rush out

violently. This is termed "blowing" by the workmen. It is mainly for the purpose of avoiding this "blowing," that the sawdust is put in the mixture, since the former, by making the mixture porous, allows the gases to escape freely.

At the end of about 36 hours the current is cut off from the furnace, and it is allowed to cool for a few hours. Then the side walls are taken down and the unchanged mixture raked off the top of the furnace, till the outer crust of amorphous carborundum is reached. The crust is cut through with large steel bars, and can then be easily removed from the inner crust of amorphous carborundum. The inner crust is next removed with a spade and the crystalline carborundum exposed.

After the carborundum has been removed from the furnace, it is taken to a crusher, which consists of a large iron pan, rotated in a horizontal plane by means of a vertical shaft. A horizontal shaft, carrying two heavy rollers, is attached to a collar surrounding the vertical shaft, thus permitting a free vertical motion of the rollers which rest in the pan. The latter, in revolving, causes the carborundum to pass under the rolls, which break the mass of crystals apart. From the crusher the carborundum is taken to large wooden tanks, where it is treated for several days with diluted sulfuric acid to remove impurities. It is then thoroughly washed, dried and graded. There are 20 grades of crystals, from no. 8 to no. 220, the numbers indicating the meshes to the linear inch of the screen through which the crystals have passed. The washings from the crystals pass through a series of tanks which serve to collect the fine powders, and from these are made the so called "flours" and the hand-washed powders. The former are obtained by floating the ungraded powders in a stream of water flowing through a series of tanks, in which the powder settles.[1] There are three grades of "flour," designated, according to their fineness, F, FF, FFF. The hand-washed powders are obtained by stirring up a quantity of ungraded powder with water, allowing this to settle for a definite time, six minutes for example, then pouring off the supernatant liquid. The powder which afterward settles from this liquid is called six minute powder. In a similar way other hand-washed powders are made—one, four, 10 and 15 minute powders.

This artificial product is rapidly replacing garnet, emery and quartz in the various industries where the latter have long been held as superior material. Carborundum grains held together by

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[1]An elutriation process similar to that employed in grading emery. *See* page 169.

some strong binding material form an abrasive surface, that is said to be more efficient for certain classes of work than the natural sandstones and grits used for grindstones and oilstones.

Carborundum is manufactured only at Niagara Falls. The output of these factories for 1902 was 3,741,500 pounds and for 1903 was 4,759,890 pounds.

Oilstone

About 20 years ago the Labrador Oilstone Co., of Manlius N. Y., quarried stone from a portion of the Portage formation which outcropped on the side of Labrador mountain in the town of Truxton, Onondaga co. This rock was milled and dressed in Manlius. It was a hard, dark blue sandstone of medium coarse grain. It had fair abrasive qualities, but imparted a rough edge; and did not compare favorably with other stones then on the market. Its sale was extremely limited, and its manufacture was abandoned.

The Pike Manufacturing Co. of Pike Station N. H. states that at one time it operated the mill at Manlius, but none of its raw material was quarried within the boundaries of New York State.[1]

Bibliography

Garnet

N. Y. State Mus. Bul. 15. 1895. p. 553–55.
——— 48th Rep't for 1894. 1895. 1:553–55.
——— Bul. 19. 1898. p. 225–26.
——— 51st Rep't for 1897. 1899. 1:225–26.
New York at the World's Columbian Exposition. 1893. p. 341–42.
Rep't Sup't State Land Sur. for 1896. 1897. p. 133–35.
Engineering and Mining Journal. 1897. No. 16. 68:461.
Min. Ind. 1901. 10:274.
——— 1900. 9:299.
——— 1899. 8:220.
——— 1898. 7:272.
——— 1897. 6:20.
——— 1896. 5:27.
——— 1895. 4:14.
——— 1894. 3:19.
Hooper, F. C. School of Mines Quarterly. January 1894. 16:124.

[1] The above history and description of this stone were kindly furnished to the writer by the Pike Manufacturing Co.

Emery

Merrill, F. J. H. N. Y. State Mus. Bul. 15. 1895. 3:555.

N. Y. State Mus. 48th Rep't, for 1894. 1895. v. 1, p. 555 (2d paging).

Merrill, F. J. H. N. Y. State Mus. Bul. 19. 1898. 4:226.

N. Y. State Mus. 51st Rep't, for 1897. 1899. v. 1, p. 226.

19th Rep't N. Y. State Geologist, for 1899. 1901. p. 151–54; *also* N. Y. State Mus. 53d Rep't, for 1899. 1901. v. 1, p. 151–54.

Williams, G. H. Norites of Cortlandt Series. Am. Jour. Sci. Ser. 3. 1887. 33:196.

Dana, J. D. Limestone Belt of Westchester County. Am. Jour. Sci. Ser. 3. 1880. 20:199.

Kimball, J. P. American Chemist. 1874. 4:321.

Lewis, J. S. Am. Inst. Min. Eng. Trans. 1893. 25:881–86.

Blue, A. Corundum in Ontario. Am. Inst. Min. Eng. Trans. 28:567.

Jenks, C. N. Tests of Abrasive Materials. Scientific American, Supplement. Dec. 8, 1894. No. 988.

Pratt, J. H. Min. Ind. 1901. 10:17.

Eckel, E. C. Min. Ind. 1900. 9:15.

Jenks, C. N. Min. Ind. 1896. 5:26.

Millstones

Min. Ind. 1898. 6:16.

N. Y. State Mus. Bul. 15. 1895. 3:527.

——— 48th Rep't, for 1894. 1895. v. 1, p. 527 (2d paging).

——— Bul. 19. 1898. 4:223.

——— 51st Rep't, for 1897. 1899. v. 1, p. 223.

13th Rep't N. Y. State Geologist, for 1893. 1894. p. 393–94, 401–5. Millstones of Ulster County; *also* N. Y. State Mus. 47th Rep't, for 1893. 1894. p. 587–88, 595–99.

Diatomaceous earth

N. Y. State Mus. Bul. 15. 1895. 3:555–56.

——— 48th Rep't, for 1894. 1895. v. 1, p. 555–56.

Fox, C. F. N. Y. Acad. Sci. Trans. 1893. 12:219.

——— N. Y. Acad. Sci. Trans. 1894. 13:98.

Carborundum

Jour. Franklin Inst. September 1893.

Carborundum, pub. by Carborundum Co. 1900. p. 5–23.

School of Mines Quarterly. November 1894. 16:73.

Acheson, E. G. History and Physical Properties of Carborundum. Min. Ind. 1897. 6:12.

MINERALS NOT COMMERCIALLY IMPORTANT

BY HERBERT P. WHITLOCK

In addition to the productive mineral deposits of commercial value, there are, in New York, many mineral occurrences which would be of economic value were it not for the fact that their small extent and costly mining render the working of them profitless as a commercial enterprise. In many cases these deposits have been worked in the past and have ceased producing because of the thinning of the ore body or on account of growing competition with the richer and more productive mines in other sections of the United States. Gold, silver and platinum, while undoubtedly occurring to a small extent both free and combined (in the case of gold and silver) with pyrite or galena, have never been found in New York in sufficient quantity to pay for the cost of extraction.

The experience of 50 years tends to show that capital invested in New York gold and silver mining ventures has invariably resulted in a loss. Gold and platinum undoubtedly exist in extremely minute proportions in the garnetiferous and magnetic sands of the Adirondack region, and in the year 1898 alone 2800 gold and silver claims were filed in the office of the secretary of state, covering portions of Saratoga, Fulton, Warren, Hamilton, Herkimer, Essex, Clinton, Franklin, St Lawrence, Jefferson and Lewis counties. The writer is however unaware that any of the holders of these "claims" have succeeded in extracting gold in paying quantities.

The minerals unimportant commercially may be roughly classified in two groups: metallic minerals and nonmetallic minerals.

Metallic minerals

1 Iron pyrites. The bisulfid of iron commonly known as iron pyrites furnishes a cheap source of sulfur in the manufacture of sulfuric acid. Within the last few years its use in this industry

has been steadily replacing that of native sulfur. It is at present mined in but one locality in New York, though it is widely distributed in small deposits. Two minerals are included in the term iron pyrites: the common bisulfid of iron or pyrite and the orthorhombic iron bisulfid which is known as white iron pyrites or marcasite.

Pyrite is frequently mistaken for gold, owing to its brassy color and brilliant metallic luster. The principal localities in New York are:

Hermon, St Lawrence co. This deposit is situated in a belt of crystalline limestone about 5 miles south of Canton and near the town of Hermon. The ore is a massive pyrite, containing 38% to 40% sulfur and 2.75% copper.[1] The mines are now being operated.

Anthony's Nose, Westchester co. A deposit of massive pyrrhotite situated on the north slope of this mountain was formerly mined, but has been abandoned for some time.

Philip's ore bed, Putnam co. This constitutes a vein of magnetite of considerable extent in gneiss and was traced by Mather[2] for a distance of about 8 miles along the crest of the east ridge of the Highlands in the towns of Putnam Valley and Phillipstown. It was formerly worked at a number of places for magnetic iron ore. The limestone which here lies next to the gneiss carries considerable pyrite.

Deposits of a similar nature also exist at Paterson, 5 miles southeast of Carmel, and near Ludington mills in Putnam county.

Wurtsboro, Sullivan co. Pyrite occurs in this locality in cubic crystals associated with galena, sphalerite and chalcopyrite. The mine which was formerly worked for lead was abandoned about 12 years ago.

Root, Montgomery co. A deposit of massive pyrite associated with galena occurs at Flat Creek in this town about 1½ miles southeast of Spraker's Basin. The deposit was formerly worked for lead, but was soon exhausted.

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[1] U. S. Geol. Sur. 1883–84. p. 879.

[2] Beck. Natural History of New York. p. 10.

Duane, Franklin co. An extensive bed of massive pyrite occurs in this town near the road leading to Malone.

Martinsburg, Lewis co. Crystallized pyrite in the form of modified octahedrons occurs in a vein of galena which traverses the limestone.

Schoharie, Schoharie co. Pyrite in well crystallized forms, single or in clusters, occurs in the limestone about 1 mile west of the courthouse.

Rossie, St Lawrence co. At the Rossie lead mines, which formerly produced considerable galena, large, brilliant and highly modified crystals of pyrite were obtained. These mines, however, have been abandoned for so long that it is difficult at present to obtain even cabinet specimens.

Eighteen Mile creek, Erie co. On the shore of Lake Erie near Eighteen Mile creek, pyrite occurs quite abundantly in the slate.

Marcasite, the white iron pyrites, do not occur to any extent in New York State, though small crystals have been found in the cement mines at Rondout, Ulster co.

2 **Arsenical pyrites.** Two compounds of arsenic and iron are here included: a sulpharsenid of iron known as arsenopyrite or mispickel and a diarsenid of iron of somewhat variable composition known as löllingite or leucopyrite. Both minerals are used to a limited extent in the manufacture of white arsenic. Owing to their brilliant, white, metallic color, they are often mistaken for silver ores, but, though the arsenopyrite of New South Wales frequently carries gold, precious metal has never been extracted from arsenical pyrites in this section of the United States. The principal New York localities follow.

Edenville, Orange co. Both arsenopyrite and löllingite occur in this locality; the former in both crystallized and massive varieties associated with gypsum and orpiment and embedded in white limestone; and the latter distributed throughout a black hornblendic diorite.

Kent and Boyd's Corners, Putnam co. This locality lies about 4 miles northwest of Carmel near Brown's quarry, a serpentine deposit which was formerly worked.

Specimens have been obtained from an old shaft about 40 feet deep, and the deposit, which consists of arsenopyrite, appears to be of the nature of a mass rather than a vein.[1] These localities have been opened but not worked for arsenic.

3 **Chromic iron ore.** Chromite, an iron chromate of variable composition, constitutes the chief source of the chromium pigments and of bichromate of potash used in calico printing. It is, furthermore, used to a small extent in the production of chromic steel.

Small amounts of chromite have been noted at the following places in New York State.

Phillipstown, Putnam co. Chromite occurs sparingly in the serpentine of Heustis's quarry about 5 miles northeast of Cold Spring. Occasional crystals have been met with in this locality.

Monroe, Orange co. Minute octahedral crystals of chromite occur at the Wilks or Clove mine about a mile south of the town of Monroe. The mineral is here found in talc associated with magnetite.

4 **Copper.** Though of relatively uncommon occurrence in New York State, copper ore is represented by several vein deposits, which were formerly worked in connection with the lead deposits in which it occurred as an associated mineral. The ore consisted of chalcopyrite, or copper pyrites, a sulfid of iron and copper. Cuprite, or red copper oxid, and malachite, the green basic carbonate of copper, also occur sparingly in isolated localities.

Copper pyrites

Ellenville, Ulster co. Chalcopyrite, in both crystallized and massive varieties, is found associated with the galena and sphalerite and disseminated through the crystallized and massive quartz. The mine, which has recently resumed work, consists of a vein of galena and sphalerite about 3 feet wide in Oneida conglomerate and is situated about $\frac{1}{4}$ of a mile from the railroad station. An incline runs to a depth of 115 feet with side galleries.

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[1] Mather. N. Y. Geol. Report. 1839

Similar deposits occur at the old Ulster mine, 1 mile east of Red Bridge, and at a mine formerly operated for lead 2 miles northwest of Wurtsboro, Sullivan co.

Ancram, Columbia co. At the Ancram lead mines about 4 miles southeast of the town of Ancram, chalcopyrite occurs in the quartz which forms the gangue in the lead-bearing veins. For a further description of this occurrence, *see under* Lead.

St Lawrence county. Chalcopyrite was found associated with the galena at the Rossie lead mine, which has long since ceased operation, and at the pyrite locality near Hermon noted under that mineral. Small quantities of this mineral have been found associated with the arsenopyrites of Edenville, Orange co., and at many other localities in unimportant amounts.

Cuprite, the red oxid of copper, has been noticed in thin seams in the diabase near Ladentown, Rockland co., a locality which also furnished an occurrence of malachite, the green copper carbonate. Both minerals here occur in extremely small quantity.

5 **Lead.** The lead deposits of New York, which were formerly worked to a limited extent, consist principally of galena, a sulfid of lead. This mineral is dark gray in color, with a cubic cleavage and metallic luster, and closely resembles metallic lead. Small quantities of cerussite, a white carbonate of lead, have been found associated with the galena in some localities.

Rossie, St Lawrence co. The lead mines of Rossie, which were operated quite extensively from 1836 to 1839, are situated about 2½ miles southwest of the village of Rossie. The deposits consist of several veins in gneiss, the largest having a width from 2 to 4 feet with an outcrop exposed for about 450 feet. The ore consisted of galena, massive or frequently crystallized in large cubes, and associated with crystallized calcite, pyrite and chalcopyrite. Shafts were sunk to a level of about 150 feet and considerable ore extracted. The workings were however abandoned in 1839, and though they were reopened for a brief period in 1852, they have been inactive for forty years.[1] Similar deposits occur in the vicinity of Macomb and Mineral Point in St Lawrence county.

[1] Smyth, C. H. jr. School of Mines Quarterly. 1903. 24:421.

Ellenville, Ulster co. This mine, which has been already referred to under copper pyrites, consists of a vein deposit of galena and sphalerite or blende; the latter is of the variety known as "black jack." The galena contains a small percentage of silver. The mine is at present operated by the Ellenville Zinc Co. of Newark N. J.

At Red Bridge, Ulster co. and at Wurtsboro, Sullivan co., similar deposits in the same formation were worked for lead, but have been abandoned for some time.

Ancram, Columbia co. Galena occurs at the Ancram lead mines, about 4 miles southeast of the town of that name, in two or three veins from 3 to 4 feet in width in slate and limestone. The ore is poor in quality, being sparingly distributed through calcite and quartz, which constitute the gangue. It is associated with chalcopyrite, sphalerite and some barite. This mine was formerly operated for lead.

Besides the above mentioned localities, galena has been found sparingly at the following places.

Schoharie, Schoharie co. Associated with pyrite.

Ossining, Westchester co. In dolomite, associated with other lead minerals in small amounts.

North East, Dutchess co. Near Smithfield, associated with chalcopyrite and sphalerite.

Guymard, Orange co. Galena occurs at Guymard about 8 miles northeast of Port Jervis. This ore occurs in a fissure vein in Shawangunk grit and is associated with sphalerite. Shafts were sunk to considerable depth, one being carried down 400 feet. The mine has been abandoned for more than 15 years.

Root, Montgomery co. 1½ miles southeast of Spraker's Basin.

Vicinity of Martinsburg, Lewis co. In the Trenton limestone associated with pyrite, sphalerite and cerussite.

6 Zinc. Sphalerite, or zinc blende, a sulfid of zinc usually carrying some iron, constitutes the only zinc-producing mineral of New York. It is found chiefly associated with galena in the lead deposits and was formerly mined with that mineral. The

localities at which sphalerite has been found have, for the most part, been described under lead; briefly enumerated they are as follows:

Wurtsboro, Sullivan co. *See* under lead.

Ellenville, Ulster co. *See* under lead.

Ancram, Columbia co. *See* under lead.

Edenville, Orange co. Opaque, black variety.

Root and Flat Creek, Montgomery co. About 2 miles south of Spraker's Basin, light yellow transparent crystals associated with galena.

Salisbury, Herkimer co. Near Salisbury Corners, associated with galena, chalcopyrite, etc.

Vicinity of Martinsburg, Lewis co. A granular, massive variety, associated with pyrite and galena.

Rochester, Monroe co. At Pike's quarry in the Niagara dolomite, associated with galena, calcite and gypsum.

Lockport, Niagara co. A honey-colored or wax-yellow variety, often in transparent crystals in the Niagara limestone.

Clinton, Oneida co. Near Hamilton College, a yellow crystallized variety, nearly transparent. Also at Rome and Vernon in the same county.

Cooper's Falls, St Lawrence co. In a calcite vein.

Fowler, St Lawrence co. Associated with pyrite and chalcopyrite in a vein traversing serpentine.

Mineral Point, St Lawrence co. Massive, in a vein of galena.

7 **Manganese.** The ores of manganese are represented in New York State by the mineral wad, earthy manganese or bog manganese, a hydrated oxid of manganese. It is of comparatively rare occurrence and has little economic value.

Columbia county. Wad is found intimately mixed with the iron carbonates and limonites of this county at Hudson, Austerlitz and Hillsdale.

Houseville, Lewis co. On Tug hill, 2 miles south of Houseville, is a small deposit, earthy in character.

Warwick, Orange co. Four miles southeast of Warwick, a compact variety is found mixed with bog ore and earthy matter.

8 Nickel. Millerite, a sulfid of nickel, is occasionally found in pockets in the hematite at the Sterling mine near Antwerp, Jefferson co. The mineral occurs in radiating, hairlike crystals.

9 Molybdenum. A sulfid of molybdenum, known as molybdenite and resembling graphite in color and luster, is found sparingly in the rocks of New York State as follows.

Warwick, Orange co. Two miles southeast of Warwick, molybdenite occurs scattered in irregular plates through granite associated with rutile, zircon and pyrite. Molybdenite also occurs at West Point in this county.

Phillipstown, Putnam co. In the gneiss adjoining the Philips ore bed. *See* iron pyrites.

Brewster, Putnam co. Associated with serpentine and magnetite at the Tilly Foster mine.

Clinton county. Sparingly distributed through the granite rocks.

Nonmetallic minerals

1 Fluorite. Fluorite, or fluor spar, a fluorid of calcium, is found to some extent in St Lawrence county as well as in less important localities in the State. Fluor spar is used principally as a flux for iron, in the manufacture of opalescent glass and as a source of fluorin in the manufacture of hydrofluoric acid.

Macomb, St Lawrence co.[1] A cavity containing about 15 tons of finely crystallized fluorite in sea-green cubes, the latter often 12 inches on edge, was discovered in this town in 1889. The deposit was found in working a small vein in limestone, and the material, which furnished beautiful specimens, has been mostly distributed throughout mineral collections and cabinets. Smaller deposits of similar material have been found at the lead mines of Rossie and at Mineral Point, Hammond, Fine, Gouverneur and DeKalb in the same county.

Muscallonge lake, Jefferson co.[1] A deposit of flourite which was quite extensively worked 50 years ago occurs on the south-

[1] Kunz, George F. Am. Jour. Sci. Ser. 3. 1889. 38:72.

east bank of Muscallonge lake about 4 miles northwest of Oxbow. The material, which closely resembles the Macomb fluorite and occurred in a vein of considerable width in limestone, is now exhausted. Fluorite has also been noted at Vrooman's lake about 2 miles east of the above locality.

Rochester, Monroe co. Fluorite occurs in the Niagara limestone at Pike's quarry.

Fayetteville, Onondaga co. Fluorite occurs in deep purple cubes associated with gypsum.

Theresa, Jefferson co. Fluorite occurs here associated with calcite and quartz.

Lockport, Niagara co. Fluorite occurs in the Niagara limestone associated with calcite, dolomite, gypsum etc.

Lowville, Lewis co. Green and nearly transparent crystals of fluorite occur in narrow veins in the limestone associated with calcite, pyrite and galena.

Johnsburg, Warren co. Beautiful crystals of fluorite have been found in this locality.

2 **Phosphate rock.** Apatite, a calcium phosphate of variable composition, is not found in New York State in deposits of sufficient extent to warrant its being mined as a fertilizer. The amorphous nodular phosphates, which in the southern Atlantic States constitute beds of considerable economic importance, are for the most part absent from New York formations.

Crown Point, Essex co. A fibrous, mammillary variety occurs 1 mile south of Hammondsville in this town. Crystallized apatite is also found associated with magnetite in many of the iron mines of Essex and Clinton counties.

Hammond, St Lawrence co. Large green and light blue crystals in calcite.

Gouverneur, St Lawrence co. About a mile southwest of Gouverneur, crystallized apatite occurs in limestone associated with quartz and wernerite.

Vrooman's lake, Jefferson co. Apatite occurs here crystallized in the limestone.

Natural Bridge, Lewis co. Imperfect crystals of apatite occur in decomposed white limestone near Natural Bridge, associated with orthoclase, wernerite, pyroxene and titanite.

Greenfield, Saratoga co. Reddish brown apatite occurs in a granite vein in the town of Greenfield about a mile north of Saratoga Springs.

Amity, Orange co. Two miles south of Amity, in a vein of white limestone, apatite is found in well defined crystals of a bright green color.

3 **Barite.** Barite, or barytes, the sulfate of barium, is often termed heavy spar on account of its relatively high specific gravity. Pure barite is rarely found in considerable masses, and the impure mineral as mined is invariably subjected to a careful sorting and refining treatment before being placed on the market. It is used as an adulterant for white lead and also to give weight and body to certain kinds of paper and cloth. Small deposits of barytes occur in a number of places in New York State.

Pillar Point, Jefferson co. Barite occurs on the Lee farm situated on the north shore of Pillar Point. The deposit consists of a vein of massive barite in limestone, which appears to run out into the bay for some distance. This vein was quarried about 40 years ago for paint adulterant.

Richville, St Lawrence co. Barite occurs here in translucent crystals with well defined terminations associated with calcite. At Hammond, De Kalb, Gouverneur, Rossie and Mineral Point in the same county similar occurrences have been noted.

Schoharie, Schoharie co. A fibrous variety of barite, grayish white or bluish white in color, occurs about 8 miles northwest of Schoharie courthouse in the town of Carlisle, between layers of dark colored slate. Also as a lamellar variety near the courthouse in waterlimestone associated with strontianite.

Little Falls and Fairfield, Herkimer co. On the south side of the Mohawk river opposite Little Falls, barite occurs crystallized in veins and geodes in the calciferous sandstone. It is white or bluish in color and sometimes transparent. Near the towns of

Little Falls and Fairfield a lamellar yellowish white variety has been observed.[1]

Syracuse, Onondaga co. At a point about ¾ of a mile east of Syracuse, crystallized barite is found in interlacing crystals associated with celestite in limestone.

Ancram, Columbia co. A white massive variety of barite occurs at the Ancram lead mine in veins traversing slate and limestone.

4 **Celestite.** Celestite, the sulfate of strontium, is used to some extent in the production of nitrate of strontia for the manufacture of fireworks. Its value for this purpose consists in its property of imparting a brilliant crimson color to the flame. The demand for it is however small, and it is not mined within the limits of New York State. Small deposits of celestite have been noted at the following localities.

Lockport, Niagara co. Celestite occurs at Lockport in grayish blue crystals, often semitransparent, in geodes in the limestone associated with calcite, dolomite and gypsum. Also in opaque white or bluish white lamellae and coarsely fibrous masses.

Rossie, St Lawrence co. At the Rossie lead mine celestite is found in delicate blue crystals associated with calcite.

Jefferson county. Near Starkville, Brownville, Depauville, Chaumont and Theresa.

5 **Magnesite.** Magnesite, a carbonate of magnesium, has a limited use in the manufacture of magnesium salts, such as Epsom salts, magnesia etc., and in the manufacture of paint, paper and fire brick. Small veins of magnesite occur in the serpentine formations of New York in several localities, but nowhere in commercial quantities.

Rye and New Rochelle, Westchester co. At New Rochelle and the vicinity of Rye and Port Chester the serpentine outcrops contain veins of magnesite. The mineral is massive, white in color and breaks with a conchoidal fracture somewhat resembling that of unglazed porcelain.

Tompkinsville, Richmond co. Magnesite here occurs in thin veins and cavities in serpentine.

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[1] Beck, Lewis C. Natural History of New York. Mineralogy. 1842. p. 205.

Warwick, Orange co. A small outcrop of serpentine shows an association of magnesite in places.

Stony Point, Rockland co. Occurrence similar to that at Warwick.

6 Mica. Three distinct minerals are included commercially under this head. They are:

1 Muscovite or white mica, ordinarily known as isinglass

2 Biotite, or black mica

3 Phlogopite, or amber mica

Chemically the micas are all silicates of magnesium and aluminum; the black and amber micas also contain iron. Muscovite is extensively used in the doors of stoves and furnaces and for lamp chimneys, where its transparency and resistance to heat render it particularly valuable. Recently muscovite and phlogopite have been utilized as insulating material in electric apparatus, particularly for the armatures of dynamos. Ground mica, which is classed commercially as " scrap mica " as distinct from " sheet mica " described above, is used in the manufacture of wall paper. Mica is a common constituent in many of the rocks of New York and occurs in sheets in several localities.

Warwick, Orange co. Eight miles southwest of Warwick near Greenwood lake, muscovite occurs in a feldspar vein in plates sometimes a foot in diameter.

Monroe, Orange co. A deposit of greenish mica occurs in augite rock near Mombasha pond. The mineral is found in good sized plates and is now being mined.

Both muscovite and phlogopite are found in plates of varying size throughout Orange co. in the granite and gneiss rocks and at the contact of these rocks with limestone.

Pleasantville, Westchester co. A deposit of mica was at one time opened and mined at this locality, but has been abandoned.

Henderson, Jefferson co. A yellow, somewhat copper-colored mica, probably phlogopite, occurs in large plates near Henderson.

Pierrepont, St Lawrence co. At a point 1 mile north of Pierrepont muscovite occurs in plates which are often 7 inches across.

Edwards, St Lawrence co. Muscovite in plates and large prismatic crystals occurs at Edwards.

Elsewhere in St Lawrence county, muscovite and phlogopite are found in small amounts and, for the most part, in dark colored varieties.

7 Coal and lignite. Coal and lignite, while they occur in New York, can never be found in commercial quantities. The coal measures of Pennsylvania are not found north of the boundary line between Pennsylvania and New York, and what coal has been discovered in the latter state is in older formations, which do not contain this valuable mineral in commercial quantities. Many thousands of dollars have been spent in fruitless efforts to obtain coal in New York, but year after year persons who seem anxious to pay for their own experience appear in the field. It can not be too strongly urged on the attention of the people of the State that it is absolutely useless to seek for coal in New York.

Woodstock, Ulster co. Coal was formerly found in a thin vein in the Catskills. The vein is worked out.

Coal also occurs in seams interstratified with shales in Chautauqua, Erie, Livingston and Seneca counties.

Rossville, Richmond co. A thin seam of lignite, or brown coal, occurs in clay.

Lignite is also found sparingly in the clays of Suffolk county.

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NEW YORK STATE MUSEUM.

PLATE 4
23RD ANNUAL REPORT

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.

Datum is mean sea level.

DISTRIBUTION OF HUDSON SCHIST AND HARRISON DIORITE

IN THE

WESTCHESTER COUNTY AREA OF THE OYSTER BAY QUADRANGLE

BY F. J. H. MERRILL ASSISTED BY H. C. MAGNUS

In 1900 that portion of the Oyster Bay quadrangle which falls on Long Island was mapped in detail by Prof. J. B. Woodworth and published in State Museum bulletin 48, entitled *Pleistocene Geology of Nassau County and Borough of Queens.* The northwest corner of this quadrangle falls within the limits of Westchester county and includes portions of the towns of White Plains, Scarsdale, Mamaroneck, Harrison and Rye. During the field season of 1903 Mr Harry C. Magnus has completed the mapping of the crystalline rocks of this district according to the classification and succession adopted by the author in the New York city folio. As no new points were developed in the course of Mr Magnus's work, the rock descriptions given here are identical with those used in the New York city folio. The map is of interest to students and teachers of the New York city region as supplementing the Harlem sheet published in the folio above mentioned.

Hudson schist. The schist of the New York district receives the name Hudson because it continues northward and connects stratigraphically with the great area of slate and shale along the Hudson river which have been called respectively Hudson slate and Hudson shale. The Hudson schist, Hudson slate and Hudson shale represent different phases of alteration of the same original rock, and together they form the Hudson formation. The Hudson formation continues into New England and is there a schist, which has been called the Berkshire schist.

The rock is essentially a mixture of biotite and quartz, but frequently contains enough orthoclase to give it the composition of gneiss. The principal accessory mineral is garnet, which occurs in crystals varying from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch in diameter.

Occasionally much larger crystals are found. Microcline, fibrolite, cyanite and staurolite are also frequent accessories. The Hudson schist has a marked schistosity, which is frequently, though not always, nearly parallel to the bedding.

The aspect of this formation is intimately affected by numerous igneous intrusions and injections of granitic and basic material, which in some places are so numerous as to predominate over the schist. The small masses are, for the most part, parallel to the schistosity, though occasionally oblique to it. The larger areas usually have their longer diameters parallel to the strike of the schistosity. They are most abundant near the shores of Long Island sound.

Harrison diorite. This rock is intrusive in the Hudson schist in the towns of Mamaroneck, Harrison and Rye. It consists of quartz, feldspar, hornblende and biotite, with accessory titanite and garnet, and less frequently apatite. The feldspars are orthoclase and plagioclase (probably oligoclase andesin) in about equal amounts, the two together making up nearly two thirds of the rock. The mass which forms Milton point, near Rye, has been subjected to much dynamic action and is well banded. The same rock is abundant along the shore of Long Island sound between Port Chester N. Y. and Stamford Ct. A small area of similar rock occurs at Ravenswood L. I., where it outcrops in a long, narrow ridge of northeasterly trend and is intrusive in the Fordham gneiss.

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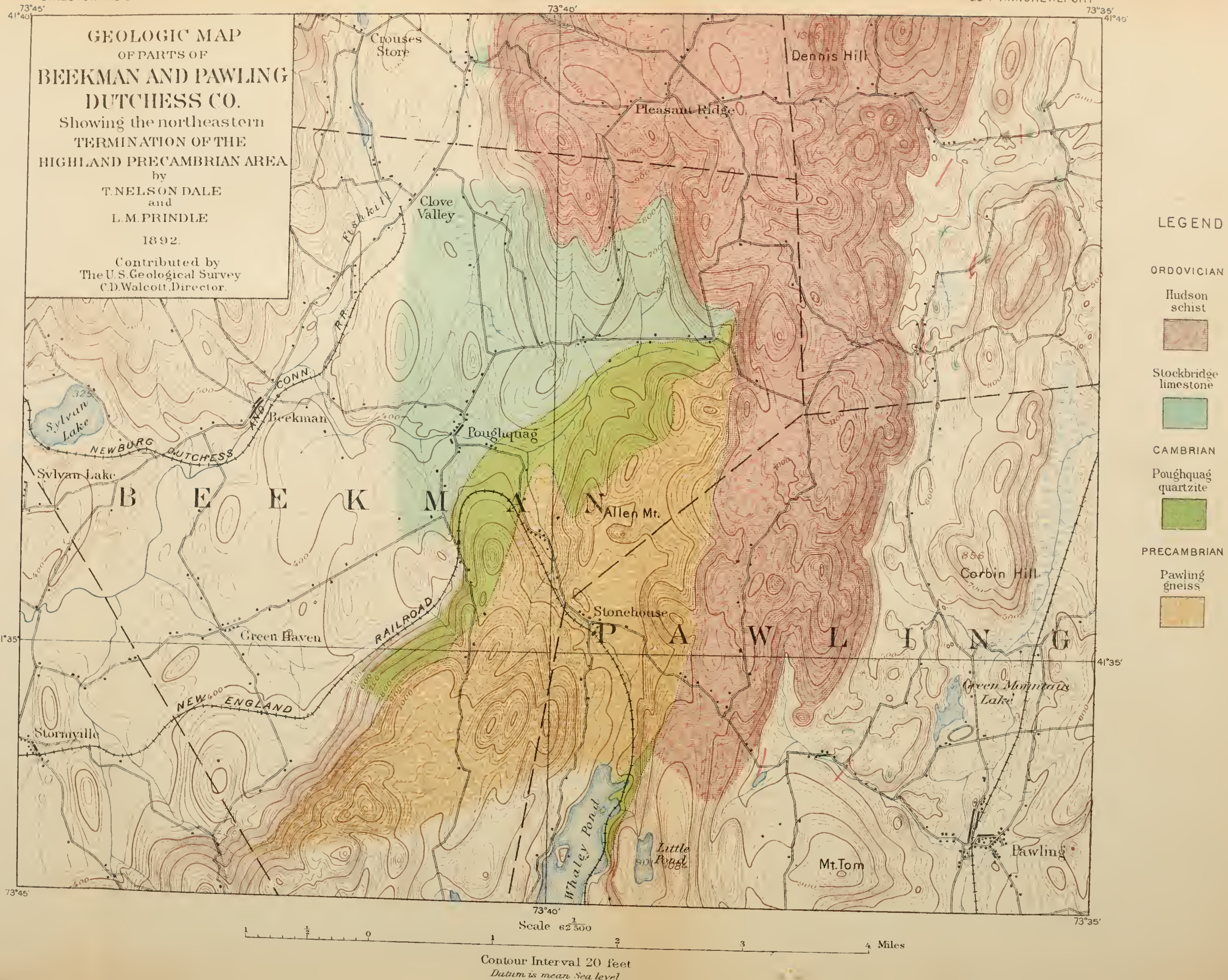
PLATE 5
23RD ANNUAL REPORT



THE NORTHEAST EXTREMITY OF THE PRE-CAMBRIAN HIGHLANDS

BY F. J. H. MERRILL

With map by T. Nelson Dale

The northeast extremity of the Precambrian highlands of Putnam and Dutchess counties lies in an area of great geologic interest. This is due to the fact that the exposures there afford opportunity for the correlation and comparison of the crystalline formations of southeastern Dutchess county, with those of southern Putnam and Westchester. Reconnaissance surveys of this region were made during the period between 1896 and 1902 by F. J. H. Merrill and his assistants Benjamin F. Hill and Edwin C. Eckel. In August 1903, being in Pittsfield, the State Geologist had an opportunity of seeing a field map of a part of the district made in 1892 under the direction of Professor Raphael Pumpelly, by T. Nelson Dale and L. M. Prindle, field assistant. This map was on the scale of 2 miles to the inch and was so complete in minute detail, that it attracted the attention of the writer and Professor Dale kindly offered him the use of it for publication, subject to the approval of Director Walcott. The permission of the latter was most cordially given and the map appears in illustration of this paper. Professor Dale's notes are records of the outcrops and express no conclusions concerning the formations, the discussion on which is based on the writer's own studies in the district.

The area in question falls on the Clove topographic quadrangle, a portion of which is colored geologically to illustrate this paper. The rocks of the region are a Precambrian formation of gneiss; a basal Paleozoic quartzite of Lower Cambrian age; a Cambro-Silurian limestone, stratigraphically equivalent to the Stockbridge; and a highly metamorphosed crystalline schist, of Hudson age, equivalent to the Berkshire schist of the New England geologists.

Near Poughquag village is a most extensive exposure of the basal Cambrian formation which from this locality has received

the name of Poughquag quartzite. This name, originally suggested by Dana, was adopted in the New York city folio as a substitute for the name Lowerre previously used by the writer and for the name Cheshire which had been, for some time, used in New England as a designation for this basal deposit. One of the reasons for this substitution was, that in the railroad cut southeast of Poughquag station, a Lower Cambrian fossil, *Hyolithes* sp. was found in the quartzite by Professor Dale and collections of it were made there by the man who acted as collector for Professor Dale. The name Poughquag has, therefore, a chronologic value as a designation for this formation because this locality has yielded Lower Cambrian fossils while at Cheshire Mass., no organic forms have yet been discovered.

The geologic structure in this area is not complex and the relations of the formations are clearly suggested by the map. The long contact of schist and gneiss was regarded by Professor Dale as a fault line but careful study of the region by the writer leads him to the opinion that it is more probably a case of overlap.

Professor Dale's party made no special study of the gneiss and schist and detailed petrographic examinations of these rocks in this district have not yet been made. The latter is a fine grained, hydromica schist and, at a point one half mile east of the contact, contains a considerable percentage of carbon in the form of graphite. The Precambrian gneiss in this region has some distinctive characters which are described as follows:

During the past 20 years the writer has been occupied, in the intervals of other work, with the study of the crystalline rocks of southeastern New York. The first task[1] accomplished was the differentiation of the principal members of the crystalline area and the determination of the structural relations of the quartzose and micaceous rocks to the great crystalline limestone which for many years was the only member accurately differentiated. With the identification of the Hudson schist and Poughquag quartzite came the recognition below the limestone of

[1] Am. Jour. Sci. 3. 39:383–92.

a great formation of banded gneiss, cut and injected at many points by later eruptives and of which nothing more could be said than that it was Precambrian.

After extended reconnaissance and local study, in the Precambrian area, certain conclusions have been reached which make it possible to express more definitely the character of the Precambrian formations.

In the vicinity of New York city the prevailing rock is a gray and black banded gneiss, the gray bands consisting of quartz, orthoclase and biotite and the dark bands containing much biotite with some hornblende. With local variations in the proportions of the two materials of its banding, the general character of the rock persists throughout the Precambrian areas of Westchester county and it may be recognized here and there along certain lines in Putnam county, chiefly on the lower slopes of the mountain ranges as a rule showing a predominance of the lighter colored rock which is essentially a white feldspar gneiss with a small amount of biotite. The same characters prevail as one passes northeastward through Dutchess county over the Poughquag area and to Dover mountain and its Connecticut extension, the Kent-Cornwall area of Percival[1] who used the following description.

> The predominant rock of this formation is the white felspathic, dark mica-seamed granitic gneiss, varying, by the different proportions of its feldspar and mica, from a nearly white, thicker, more granitic variety, to a lighter or darker gray, thinner and more schistose variety.
>
> These variations occur in alternate beds, one or the other predominating in different sections of the formation.

Passing farther northeastward into Massachusetts one encounters the Becket gneiss formation of Emerson which has in places the same general characters.

The facts intended to be shown by the map are self-explanatory. Details of the geology of the Precambrian rocks are reserved for a separate paper on this subject which the writer has now in preparation.

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[1]Percival. Report on Connecticut. New Haven 1843.

PALEONTOLOGY

The State Paleontologist reports that during the year investigations have been carried forward with special reference to the problems of the correlation of the earlier Devonic faunas of New York with those of the maritime provinces of Canada; also with reference to the development and correlation of the graptolite faunas in this State. The latter investigations have been brought to a conclusion and are in course of publication as Memoir 7 of the State Museum. The final investigations necessary for the conclusion of the study of the faunas of Portage time in New York have been completed and are embodied in Memoir 6, which is now essentially printed. During the year, Memoir 5 on the Guelph fauna of the State of New York was printed and distributed. Bulletin 65, *Catalogue of Type Specimens of Paleozoic Fossils*, was also completed and issued.

During the greater part of the year the printing of the annual report for 1902 has been in progress, and this is now ready to leave the press. An indication of the activity of the department in the direction of publication for the year is afforded by the statement that our printed investigations and reports equal 1600 pages, accompanied by 68 lithographic plates.

Heretofore in the history of the department but little attention has been given to the study of the fossil plants from our Paleozoic formations. During the year Mr David White, of the United States Geological Survey, has made a preliminary examination of our material, and arrangement has been made with him for future careful study of the more interesting of the extensive series of striking specimens of these ancient plants which our collections contain.

The additions to the collections have been large, as acquisitions have been freely made in the field. At present the sum total of acquisitions may be estimated at from 10,000 to 15,000 specimens, among which is an important series of type specimens of graptolites and other fossils acquired by purchase. We are also acquiring a unique slab of Potsdam sandstone, 30 x 10 feet, bear-

ing a most remarkable display of trails made by trilobites or mollusks. This specimen is from Clinton county, where it was long known to the inhabitants, but was brought to public notice by Prof. J. B. Woodworth in a paper published by this department.

The stratigraphic and paleontologic maps of the Canandaigua and Naples sheets have been completed and will be presently issued as a bulletin of the Museum.

The death of Philip Ast, who has been lithographer for a period of more than 30 years, left a vacancy, which has been filled by the appointment of William S. Barkentin.

During the latter part of the season of 1902 and in the field season of 1903 Dr Ruedemann was engaged in field operations in Rensselaer and Washington counties, where, by the discovery of certain horizons of graptolites, it became possible to find a definite contact line of the Cambric and Lower Siluric formations. His study of the graptolite faunas of the older rocks has led him to cover a considerable part of northern Rensselaer and Washington counties in such detail as to furnish an accurate stratigraphic map of this region. Dr Ruedemann has also restudied the occurrences of the slate beds bearing graptolites in the vicinity of Hudson, Columbia co. For the greater part of the season he has been engaged, in continuation of previous operations, in collecting materials for a careful analysis of the Lower Siluric (Beekmantown and Chazy) faunas in the Lake Champlain basin, his collections and field operations having covered, throughout the entire length of the lake, all the leading outcrops, many of which were heretofore unrecorded, and which are sufficient to form the basis of an exhaustive examination of these faunas.

Mr D. D. Luther has completed the acquisition of the data necessary for stratigraphic maps of the Elmira and Watkins quadrangles. He has also made a careful reconnaissance of the Waverly and Ithaca quadrangles on the east, and, with a small amount of additional work, it will be possible to color these sheets. Reconnaissance has likewise been made of the region to the west of Elmira and Watkins sheets. Some time has also been

spent by Mr Luther in the study of the Hammondsport quadrangle with reference to continuing the stratigraphic coloration from the Naples sheet eastward.

Mr Gilbert van Ingen, who resigned his connection with this department in May to accept the position of curator of invertebrate paleontology in the E. M. Museum, Princeton University, was engaged during the latter part of last season and into the winter in the preparation of an account, stratigraphic and paleontologic, of the complicated region about the cement quarries of Rondout, Ulster co. His solution of this problem is published in the annual report of the department.

Mr C. A. Hartnagel continued his study of the relations of the Cobleskill limestone by field work from Port Jervis northward to Kingston and in central New York about Cherry Valley, Manlius, Jerusalem hill and westward. The results of Mr Hartnagel's investigations are now published.

Prof. A. W. Grabau has prepared a stratigraphic map of the classical Schoharie valley region from Schoharie courthouse south to Middleburg. This section is the longest and best known of any of the Paleozoic rock sections of the State, but no detailed map of the succession has heretofore been prepared.

During the summer Mr G. H. Chadwick was employed in making a traverse of the higher Catskill mountain sections and in collecting material for the study of the fauna of the Port Ewen beds at and about Kingston and also in acquiring the fine Oriskany fossils of Glenerie, Ulster co.

The Paleontologist has spent some time in making extensive collections of the interesting lower Devonic fossils from the limestones at Percé, Province of Quebec, with reference to the completion of the correlation study of the New York Lower Devonic with the faunas of equivalent age in the eastern or Atlantic provinces.

GENERAL ZOOLOGY

At the beginning of the year the Assistant in Zoology was engaged in a study of the market relations of the edible crab, and a short account was given in the last Museum report.

As it appeared that the economic importance of the crab in New York did not justify further work in that direction, the preparation of a catalogue of the invertebrates of New York city was begun, and the principal work of the year has been the collection of material for that purpose. October 1902, the spring months and September 1903 were therefore spent in New York city, and a considerable amount of invertebrate material was collected, much of which was, before, either poorly, or not at all, represented in the Museum collections. In continuation of the work on a catalogue of the Batrachia of New York, begun some time previously, three weeks were spent in the Adirondacks, where much myriopod material was also obtained. In vacation a trip was also made to Bermuda, and some interesting forms for the type series were brought back.

The winter months were spent partly in identifying the material collected, and a visit to the Harvard University museum was made for the purpose of comparing the myriopod and phalangid material on hand with the specimens there.

In the exhibition series numerous changes were made. Some of the smaller mammals were removed from the large end case and placed in one of the center cases, and the central end case was used as an alcove for vivaria. The duplicates were removed from the series of mammalian skeletons, and the remainder were placed in one of the wall cases against a black background. The skulls were put in one of the table cases.

The birds have also undergone a considerable rearrangement, and the foreign birds and the duplicate specimens have been removed from exhibition and stored in the upper third of the wall cases, a space useless for exhibition purposes. The nests, which were formerly in a case by themselves, have been placed in the general series of birds along with their appropriate specimens. These changes resulted in giving more space, so that it was possible to use two of the smaller wall cases for birds and give the two large east center cases to invertebrates, a position where they would have better light.

The birds' eggs have all been placed on black smalt in black boxes and show to much better advantage than formerly.

To the reptiles and batrachians some new species have been added. The additions to the series of casts of fishes mentioned in the last report have had their backgrounds painted black and have been hung along the top of the case of alcoholic fish.

Some additions have been made to the series of invertebrates, and a black background has been given to the cases of corals. A beginning has also been made in the preparation of a type zoologic collection, to contain forms illustrating the different classes and orders, whether confined to New York or not, and with a full series of descriptive labels.

The collection of domestic fowl, formerly the property of the New York State Agricultural Society, has been rearranged, and a portion of it placed on small polished bases.

The vivaria, containing several species of common reptiles and batrachians, have been continued through the year and are apparently objects of considerable interest to the public.

Dr Farr expects soon to send in the first part of his report on the birds of New York, and Miss Letson has nearly completed her check list of the New York Mollusca.

ENTOMOLOGY

The State Entomologist reports that the season of 1903 has been remarkable for the abnormal abundance and destructiveness of plant lice of various species, and that the grapevine root worm continues to inflict severe injuries in the Chautauqua grape belt.

Extended studies of this grape pest have been prosecuted during the season and a thoroughly practical method of controlling the pest, demonstrated. Many valuable data have been obtained, and an account of the work will appear in a revised and extended edition of Museum bulletin 59. Experiments with various insecticides for controlling the San José scale have been continued in the vicinity of Albany and also in Orange county and some most gratifying results obtained. A second instalment of the beneficial Chinese lady beetle, which may prove of value in suppressing this pest, has been obtained from the United States Department of

Agriculture and established in an infested orchard at Kinderhook. The studies of forest and shade trees have progressed satisfactorily. Early in the season the extended forest fires afforded an excellent opportunity for ascertaining the connection between them and insect depredations, an investigation which is still in progress.

Dr James G. Needham has continued his studies on material collected at the entomologic field station at Saranac Inn in 1900 and has nearly completed an extensive report on the stone flies and May flies of the State. The studies of mosquitos have absorbed considerable time and resulted in securing many desirable specimens with important data respecting the same. Cooperative work with the North Shore Improvement Association, well and favorably known because of its mosquito crusade in the vicinity of New York city, has been undertaken with mutual benefit.

The Entomologist has made numerous contributions of a practical nature to agricultural papers, and, aside from bulletins issued by the Museum, has prepared two important papers; one on insects injurious to pine and oaks, for the 7th report of the Forest, Fish and Game Commission and one on insecticides for the report of the Colorado State Board of Horticulture.

Other important publications, which are either in the printer's hands or practically completed, are as follows: *Grapevine Root Worm*, a revised and extended edition of Museum bulletin 59; *Monograph of the genus Saperda*, prepared by the Entomologist in cooperation with Mr L. H. Joutel; and Dr Needham's 3d report, which will be a work of about the same size as Museum bulletin 68. There is also a memoir on insects injurious to forest and shade trees, an extensive publication illustrated with many half tones and 16 colored plates.

Large and valuable additions have been made to the State collections during the past season, some most desirable specimens being secured from sections of the State hitherto poorly represented. There has been much progress in arranging the insects, and substantial additions have been made to those on exhibition. During the past summer, a system of exchange was begun and

many valuable species obtained with practically no expense to the Museum.

The routine work of the office has progressed as usual, and a gratifying interest is shown by the large increase in the correspondence. The reports of voluntary observers, and lists of the publications of the Entomologist and of contributions to the State collections, contained in the State Entomologist's reports, are records of other activities of the office.

BOTANY

During the past summer the field work of the State Botanist has been largely devoted to the study and collection of specimens of the species of thorn trees and shrubs growing in the eastern and northern parts of the State. The number of new species of the genus Crataegus found in the United States and published in recent years is very great. It is therefore important that a better knowledge of our New York species and a better representation of them in the herbarium should be had, if we would keep pace with the progress made in this botanic field. Specimens of many species and forms not before represented in the herbarium have been collected. The most prolific stations have been visited two or more times in order to obtain specimens showing the flowers, the young fruit and fully developed leaves and the mature or ripe fruit.

The investigation of our fungus flora has been continued as opportunity was available, but, owing to an unusual scarcity of the fleshy species of mushrooms in this part of the State, the collections have not been large.

For greater security against the attacks of insects and the defilement of dust, the plan of placing specimens of our larger fungi in covered pasteboard boxes has been adopted, and a considerable number of specimens, including extra-limital ones, have been arranged in this way. In order to economize in the use of space, the boxes have been made of various sizes but multiples of each other, a large box being used for large specimens and a small one for small specimens.

A series of specimens of economic interest has been placed in trays for the purpose of putting them on exhibition in show cases.

ARCHEOLOGY

During the past year Dr Beauchamp has written, subject to revision, a complete history of the Six Nations of New York, illustrated by several early maps.

He is also writing a bulletin on the use of wood by the aborigines of New York, with 150 illustrations, showing house and fort building, armor, masks, canoes, household and hunting articles.

He has prepared a report on the Perch lake mounds of Jefferson county, with maps and sketches of mounds. In this he has had the aid of friends, and it is ready for use when required. To this bulletin he has added brief notes on other New York mounds and some account of Indian trails.

He has now in hand a paper on Indian councils, including the condolence or mourning council, religious and general councils. In the former are included the condoling songs, and for some of these he has secured the music. On his personal account he has contracted for a number of Onondaga songs and music, a very desirable thing, but the Museum is not responsible for these. Incidentally he has made desirable notes for future work, and many notable relics have come before him, suggestive of a supplementary bulletin.

ATTENDANCE AT THE MUSEUM

Oct. 1, 1902–Sep. 30, 1903

Total	78 871
Monthly maximum, August	8 737
Daily maximum, Feb. 23	834
Average, monthly	6 572
Average, daily	253

The following is a comparison of the turnstile records for the past seven years, showing the averages of yearly, monthly and daily attendance.

	Average Yearly	Average Monthly	Average Daily
Oct. 1, 1893–Sep. 30, 1894.......	72 185	6 015	233
Oct. 1, 1894–Sep. 30, 1895.......	61 368	5 114	197
Oct. 1, 1895–Sep. 30, 1896.......	52 003	4 333	170
Oct. 1, 1896–Sep. 30, 1897.......	53 366	4 447	175
Oct. 1, 1897–Sep. 30, 1898.......	54 907	4 575	180
Oct. 1, 1898–Sep. 30, 1899.......	55 529	4 627	182
Oct. 1, 1899–Sep. 22, 1900.......	61 370	5 114	197
Sep. 22, 1900–Oct. 7, 1901.......	Building closed for repairs		
Oct. 7, 1901–Oct. 1, 1902.......	75 598	6 299	241
Oct. 1, 1902–Sep. 30, 1903.......	78 871	6 572	253

ACCESSIONS TO THE COLLECTIONS

Mineralogy

Donations

W. C. Van Alstyne of the Tannite Co., Albany. 1 specimen corundum in orthoclase, Craig mine, Ontario Can.

H. H. Hindshaw, Albany. 1 specimen pectolite crystal, Baltimore Md.; 1 opal, Baltimore Md.; 1 serpentine, Baltimore Md.

Harold Heiser, Albany. 1 specimen gold in quartz, Telluride Col.; 4 petrified wood, Arizona; 1 graphite in dolomite, Plattsburg N. Y.; 1 silver telluride in sphalerite, Victor Col.; 1 gold, Victor Col.; 1 sylvanite in fluorite, Victor Col.; 1 sylvanite, Victor Col.

A. P. Adams, Albany. 5 specimens uranophane, southeast Utah; 1 uranophane and gummite, Colorado; 3 chalcocite, Dolly Varden claim, Utah; 2 chalcocite replacing woody fiber, Dolly Varden claim, Utah; 1 malachite replacing woody fiber, Dolly Varden claim, Utah; 9 proustite in quartz, Dolores county, Col.; 1 stibnite and proustite in quartz, Dolores county, Col.; 1 quartz, jasperized wood, southeast Utah; 1 quartz (large group of crystals) Jumbo mine, Rico Col.; 1 uranophane (large specimen and fragments), southeast Utah; 1 uranophane and gummite, Colorado; 1 chalcocite (wood replacement), Dolly Varden claim, Utah; 64 rolled pebbles hematite, southeast Utah.

Dr Joseph Simms, New York. 46 specimens native copper, Michigan, 10 native gold, 38 galena, 2 argentite, 3 pyrargyrite, 3 stephanite, 3 cerargyrite, 5 cinnabar, 2 chalcopyrite, 26 pyrite, 2 halite, 49 quartz (crystallized), 15 quartz (geodes), 26 quartz (chalcedony), 7 quartz (petrified wood), 2 opal, 6 opal (opalized wood), 17 calcite (crystallized), 36 calcite (stalactitic), 1 dolomite, Lockport N. Y., 1 malachite, 1 stilbite, 3 gypsum, 1 tourmaline, 1 magnetite (large), 5 pyrolusite (dendritic), 6 hematite.

A. S. Reid, Johnstown N. Y. 1 specimen hematite, south Hamilton county, N. Y.

G. van Ingen, Princeton N. J. 1 specimen marcasite in quartz and calcite, Rondout N. Y.

T. E. Clark, Rondout. 1 specimen pyrite (dendrite) on limestone, Rondout; 1 marcasite on calcite, Rondout; 2 dolomite, Rondout; 2 calcite, Rondout; 2 quartz (phantom crystals) Rondout.

Jacob Van Deloo, Albany. 1 specimen calcite, Rondout; 1 sphalerite, Rondout; 1 fluorite, Spier Falls N. Y.

Exchange

With **H. O. Clough**, Albany. 4 specimens allanite crystals, Topshan Me., for 1 specimen hematite from Antwerp.

Collections

H. H. Hindshaw. 1 specimen muscovite (showing secondary growth and inclusions), Batchellerville, Saratoga co. N. Y.

H. P. Whitlock. 21 specimens calcite (series illustrating types), Rondout N. Y.

Zoology

MAMMALS

Collections

1 meadow jumping mouse, *Zapus hudsonius,* Pine Hills, Albany N. Y. Skin and skull.

4 meadow mice, *Microtus pennsylvanicus,* Pine Hills, Albany N. Y. Nests.

2 domestic cat, *Felis domestica,* Pine Hills, Albany N. Y. Skull.

deer, *Cariacus* sp., Caledonia N. Y. Parts of antlers from peat bog.

1 bat, *Myotis lucifugus.* Albany N. Y.

Donation

Dr Van Slyke, Coxsackie N. Y. horse, *Equus caballus,* 5 milk teeth.

Purchase

1 opossum, *Didelphys virginiana.* Cedar Hill, Albany co., N. Y.

BIRDS

Donations

Reed Hogan, through S. C. Shaver, Cobleskill N. Y. 1 horned grebe, *Colymbus auritus.*

Miss M. R. Wilburt, Old Chatham N. Y. 1 Baltimore oriole, *Icterus galbula.*

J. H. Brooks, Albany. 1 California Bush tit, *Psaltriparus minimus,* Black Warrior, S. Arizona. Nest.

Earl J. Hicks, Albany, N. Y. 1 cedar waxwing, *Ampelis cedrorum.* Nest and 4 eggs.

Miss Edith Z. Cole, Coeymans Hollow N. Y. 4 chimney swifts, *Chaetura pelagica.* Nests.

REPTILES

Miss D. Levison, Albany N. Y. 1 painted tortoise, *Chrysemys picta.*

Mrs Wachsmann, Albany. 1 alligator, *Alligator mississippiensis.*

W. C. Fellows, Oneonta N. Y. 4 garter snakes, *Eutaenia sirtalis.*

W. Worthington, Shelter Island N. Y. 1 milk snake, *Osceola doliata triangula;* 1 blowing adder, *Heterodon platyrhinus;* 1 painted tortoise, *Chrysemys picta.*

AMPHIBIANS

Collections

4 *Gyrinophilus porphyriticus,* Shawanese lake, Pa.

3 *Desmognathus ochrophaea,* Shawanese lake, Pa.

3 *Desmognathus fusca,* Karners N. Y.

7 Cricket frogs, *Acris gryllus,* Staten Island, N. Y.

PISCES

Donations

J. W. Pond, Chatham N. Y. 1 miller's thumb, *Uranidea gracilis* (Heckel).

C. E. Marsters, Albany N. Y. 1 sunfish, *Eupomotis gibbosus.*

1 yellow perch, *Perca flavescens*

4 catfish, *Ameiurus nebulosus*

Collection

7 black lampreys, *Lampetra wilderi,* New York city.

Purchase

Casts of fishes. **Ward's Natural Science Establishment**, Rochester N. Y.

INVERTEBRATES

Donations

E. P. Vines M. D., Lansingburg N. Y. 1 tarantula.

R. L. Wadhams M. D., Wilkesbarre Pa. *Ascaris lumbricoides*

W. Worthington, Shelter Island N. Y. 75 horseshoe crabs, *Limulus polyphemus, young*

G. Gerdon, Sandy Hook N. J. 1 pile excavated by ship worm, *Teredo navalis.*

The main accession of the year were invertebrates, almost entirely collected within New York city. The Crustacea, Myriopoda and Annulata are the only groups so far worked over, and number as follows. The remaining groups are estimated.

	Species	Specimens
Crustacea		
Macrura	5	26
Brachyura	8	112
Amphipoda	17	560
Isopoda	16	926
Myriopoda	16	308
Annulata	17	103
Coelenteratae, Mollusca, Arachnida etc.	65	400
Total	144	2 435

APPENDIX

With the reorganization of the State Museum under the new Department of Education, the present Director and State Geologist retired from office on May 1, 1904. In addition, therefore, to his report for the fiscal year ending Sep. 30, 1903, it remains to append a résumé of the administrative work conducted under his direction from Oct. 1, 1903, to May 1, 1904.

During this period the time of the State Geologist was mainly devoted to the editing of the reports in hand and to the supervision of the collection of statistics relating to the mineral resources of the State. This was undertaken in cooperation with Dr David T. Day of the United States Geological Survey and involved correspondence with every mineral producer in the State. At the outset copies of the lists of producers recorded in the office of the United States Geological Survey were made and forwarded to Albany. Then after preliminary cards of inquiry had been sent from Washington to all these producers, copies of the replies received were sent to Albany and from the latter point new cards were sent to all the delinquents together with circular letters explaining the cooperation between the State Museum and the United States Geological Survey. In many cases it was necessary to send several cards to delinquents before replies were received.

The mineral resources of the State were illustrated in detail for the exhibit at the Louisiana Purchase Exposition by locating on the colored geologic map of 1901 the positions of the various mines, quarries and other openings. These were marked by small conventions of colored paper, the execution of the work being intrusted to Mr H. P. Whitlock, Assistant in Mineralogy.

The time of the Assistant in Geology, Mr H. H. Hindshaw, was occupied during the early part of the winter on drawings for the 15 mile base map of New York State and vicinity, in the tabulation etc. of information on mineral products of the State and in correspondence principally relating to questions of economic geology. Some work was also done in the preparation of plans for the St Louis Exposition exhibit.

In the autumn of 1903 Mr Hindshaw had met Dr J. A. Holmes and Dr David T. Day, as well as representatives of the iron-producing interests, and plans were formulated for the exhibit of a series of New York iron ores and the processes of their preparation for market, including a Wetherill magnetic separator.

In January, it having been finally decided that the Museum should make an exhibit at St Louis, Mr Hindshaw's time was practically all given to the work of preparation. On account of the small appropriation and little time available, it was necessary to make use of the Museum collections as far as possible. Correspondence was opened with a few of the principal producers and their cooperation asked along certain definite lines which would agree with the plans adopted. These requests were in most cases complied with, and as a result very creditable exhibits were prepared by the Mathews Consolidated Slate Co., the Hudson River Bluestone Co., the Medina Quarry Co., the Ellenville Zinc Co., the Helderberg Cement Co., and the Solvay Process Co. Other firms which were asked to contribute to this scheme thought proper to decline, principally on account of the short time available, so that the exhibit as finally planned was not as complete as desirable.

Early in March Mr Hindshaw paid a visit to St Louis to arrange about a grant of electric power which was to be furnished for running the Wetherill magnetic separator, correspondence not securing the desired results which were obtained only after several days' personal effort at St Louis.

The building stone blocks to be sent to St Louis were worked over and resurfaced. Selections were made from the collections of ores and minerals in the Museum. The packing of these and the planning and building of new stands and the preparations for shipment of these and of museum cases kept Mr Hindshaw busy all the time with the exception of four days spent in a second visit to St Louis for the purpose of making a satisfactory contract for flooring, partitions and other necessary work on our exhibit space.

On Ap. 10 Mr Hindshaw left Albany to instal the exhibit at St Louis. The installation was particularly difficult as the space allotted was too small to handle our material from the Museum till the large slab of Potsdam sandstone from the Division of Paleontology, the brick work from the Alfred School of Clay-working and Ceramics and the larger pieces of masonry had been put in place. The exhibit of brine products made by the Solvay Process Co. also needed much room for handling, while the erection of the Wetherill magnetic separator necessitated the use of extensive crib work and hoisting apparatus. The exhibit was for these reasons still in an unfinished condition on May 1, but much of it was accessible to visitors. Prepared thus under difficult limitations of time and expense, the exhibit met with a very favorable reception.

In the section of mineralogy, in charge of Mr H. P. Whitlock, assistant, work has progressed along the following lines:

A type collection of the minerals of New York State was installed in the north end of the mineral museum; the economic collection, which formerly occupied this space, being transferred to the entresol. This change, besides providing a much needed local mineral collection, has placed the latter where a constant comparison with the main systematic collection will prove most valuable. The New York mineral collection at present consists of over 600 specimens and contains much material which is of paramount scientific interest.

A representative collection of geodes from the Keokuk limestone of Iowa and Illinois, consisting of 35 specimens which were acquired by exchange, has been installed in an independent exhibit on the second floor. Three table cases along the walls of the entresol have been used for the temporary display of recent accessions.

The set of lantern slides available for lecture purposes has been added to, and now numbers 150, mostly illustrating specimens from the Museum collection.

During the winter the time of the Assistant in Zoology, Dr F. C. Paulmier, was spent mainly in the preparation of a cata-

logue of the higher crustacea of New York city. This involved the identification of the forms collected during the preceding two summers and the preparation of some 30 sketches of forms not hitherto figured.

The Myriopoda and Phalangida in the Museum were also identified, a trip to Washington being made for the purpose of comparing the specimens with the collections there. Some sketches and notes were made for a catalogue of these forms.

During the spring practically all of the attention of Dr Paulmier was devoted to the birds and in this he had the invaluable assistance of Mr William C. Richard, a taxidermist. Unfortunately the latter was not here during the hight of the spring migration, but in spite of that, about 150 birds were collected. Some of these were mounted and the remainder made up into skins for a study collection.

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Museum bulletin 77

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BULLETIN 327 JANUARY 1905

New York State Museum

Bulletin 77
GEOLOGY 6

GEOLOGY OF THE VICINITY OF LITTLE FALLS, HERKIMER COUNTY

New York State Museum

Bulletin 77
GEOLOGY 6

GEOLOGY OF THE VICINITY OF LITTLE FALLS, HERKIMER COUNTY

AREA COMPRISED IN THE LITTLE FALLS QUADRANGLE

PREFACE

The study of the crystalline rocks of the Adirondack area by modern petrographic methods was begun in 1892 by Prof. J. F. Kemp under the direction of the writer in connection with the iron ore deposits in the vicinity of Port Henry and some results were published in Museum bulletin 14, *Geology of Moriah and Westport Townships, Essex County, N. Y., with notes on the iron mines.* Subsequently this work was continued and extended under the direction of Prof. James Hall, and Professors C. H. Smyth jr and H. P. Cushing were invited to participate in the study of this great crystalline area. The work of the three investigators in their separate fields has been published in the reports of the state geologist for 1893 and subsequent years, and has resulted in a wholly new light being thrown on the structure and geologic history of the district. Professor Cushing's special field has been the Northeastern Adirondacks and having successfully covered the part alloted to him so far as the existing maps of that region would permit, it seemed that it would be of much interest to make a detailed comparison of the northern pre-Cambrian geology with that of an area bordering on the Mohawk valley. The Little Falls quadrangle having been completed, this suggested itself as a convenient and interesting field for work. Professor Cushing accordingly, as a result of a careful study of this area, communicates the following report.

FREDERICK J. H. MERRILL
State Geologist

GEOGRAPHIC POSITION

The area comprised in the Little Falls atlas sheet lies mostly north of the Mohawk river between East Canada and West Canada creeks. The Mohawk runs across the sheet near its southern edge. The Canada creeks diverge and run out of the sheet limits, East Canada to the east, and West Canada to the west, about midway between the Mohawk and the north border of the sheet. The map extends over 15′ of latitude, 43° to 43° 15′ n., and 15′ of longitude, 74° 45′ to 75° w., comprising about 218 square miles.

Its geographic association is with the Adirondack highland region and the Mohawk valley lowland. South of the Mohawk the altitude rises quickly to that of the dissected plateau region of southern New York, this being wholly without the map limits. The lowland is worn down on a belt of rocks which are weak as compared with those to the north and the south. It is much narrower here than farther west, for the reason that rocks which here are resistant and hence belong to the plateau district, become both weaker and thicker as they are followed to the west, so that the belt which they underlie becomes merged with that of the lowland.

The lowland belt is an agricultural one and has been cleared and farmed this many a year. The district occupying the northeast portion of the map belongs however with the Adirondack highland belt and is still forest covered. But lumbering has been carried on for many years around the edge of the woods, so that within the limits of the map the timber has been mainly cut and the woods are therefore very thin. Fires have however not been as frequent as in many parts of the Adirondacks, and very little of the territory has been burned over. Sporadic cutting of timber is going on even yet, mainly hardwood, with here and there a spruce, the logs being hauled out singly throughout the year. The supply is sufficient to keep several small sawmills running.

GENERAL GEOLOGY

The detailed topography of the district can not be made intelligible without a knowledge of the rock structure and the geologic history of the region, since it depends on both. The study of the

rocks has brought out the facts here given and the detailed evidence will be presented later.

Sketch of physical changes. The rocks of the Adirondack region are among the oldest of which we have knowledge anywhere on the earth's surface. The history which they disclose is an exceedingly difficult one to decipher and has been only imperfectly made out as yet. It is however clear that it involves the passage of a prodigious lapse of time.

The oldest known rocks of the Adirondack region are of the sort deposited from water, and indicate that the region, probably in its entirety, was below sea level and receiving deposit on its surface. These deposits would seem to have been of the same, or very similar, sort as those now being deposited on shallow sea floors: sands, muds, calcareous muds and their intermediate gradations. These rocks were apparently deposited in great thickness, though we have no means at present of ascertaining what that thickness was. They must have accumulated on a floor of older rocks, but this older floor has not yet been certainly made out in the Adirondack region. It may or may not be present. Volcanic action seems to have been going on while these deposits were forming, or else occurred not long afterward.

After these conditions had persisted for a long time, the district was raised up out of the water, probably to considerable hight, accompanied by a certain amount of folding, fracturing and tilting of the rocks. The surface ceased to receive deposit, and instead was attacked by the weather, the surface deposits were disintegrated and decayed, this loosened material commenced to move down hill toward the sea, and the surface was thus pared away bit by bit and lowered. This action continued through long ages till many hundred, likely a few thousand, feet of rock had been thus patiently removed.

The region also was early the scene of vigorous igneous action. Whether this preceded, accompanied and perhaps caused, or followed its uplifting above sea level is not known; but enormous masses of molten rock invaded the region from beneath in a great series of intrusions. Whether any of this material ever reached

the then existing surface, with manifestations of surface volcanic action, we do not know, likely never can know. But not improbably these masses may represent old reservoirs whence volcanic material ascended to the surface.

The old floor, on which the previous deposits had been laid down, was largely or wholly engulfed in the molten flood, as were the old deposits themselves to a large extent. These were invaded, broken up, and separated into disconnected patches by the eruptive rock, which then cooled and solidified far underground. There is a series of these igneous intrusions with varying composition. The heart of the Adirondacks felt the full force of this action. The present borders were more remote from it, the igneous rocks are less conspicuous there, and the old sediments occur in greater mass.

At some date after the igneous action had ceased, though probably commencing while it was still in progress, the rocks were subjected to strong compression, acting mainly from one side. The rocks were compressed, intricately folded, the sediments were made thoroughly crystalline, all traces of their original structures were obliterated, and a foliated structure was produced in them and in the igneous rocks as well.[1] The general process is known as metamorphism. Side pressures can not produce effects such as these in rocks near the surface, but only at considerable depth; and, since these rocks are now at the surface, it is argued that the rock covering under which they were buried at this early time has been slowly and laboriously removed by erosive processes during the long ages that have since elapsed. They were likely at a depth of at least from 3 to 5 miles below the surface at this time.

The region persisted above sea level for a long time, during which likely occasional movements of further uplift were in prog-

[1]Under the temperature conditions which prevail at considerable depth and specially if moisture is present, high pressure produces rearrangement of the rock particles, mainly through recrystallization. The minerals form newly, mainly along certain dominant planes, and thus give the rock a layered arrangement. In sedimentary rocks this may or may not correspond with the old bedding planes. This layered arrangement of the constituent minerals constitutes foliation. Often ready splitting may be produced along these planes because of the concentration of a mineral with good cleavage there.

ress. As the surface was worn away, the present surface rocks were brought that amount nearer to the surface and were under the load of a constantly diminishing amount of overlying rock. From time to time renewed side pressures were brought to bear, these likely coinciding with times of renewed uplift and disturbance. But, as the rocks approached the surface in this slow fashion, the effects produced on them by the pressure would change in character. The pressure seems also to have been less pronounced than in the former stage and to have been mainly effective in producing joints.[1] Likely slipping and faulting also took place, but if so the faults have not yet been differentiated from those of a much later period.

Toward the close of this long erosion period, after much the larger part of the overlying rocks had been worn away, volcanic activity was renewed in the Adirondack region. The main center of the activity of this period was in the northeastern Adirondacks, and igneous rocks of this period make but little show in the south. They used mainly an eastwest set of joint planes for their ascent. We do not know whether any of this material reached the surface or not. If so, all traces of the surface materials have been since worn away. Nor has erosion anywhere cut deeply enough to disclose the old reservoirs whence these lavas arose, though they were the same in all probability as those whence came the material for the earlier great intrusions. We find exposed at the surface of today merely the old, lava-filled fissures which served as the channels of ascent for the molten rock. The surface outflows have disappeared through erosion and the original reservoirs are still buried in depth.

These rocks are known to be distinctly later than the other igneous rocks by various sorts of evidence. The dikes (the filled fissures) of the later rocks cut through the earlier. The later rocks are not metamorphosed as are the earlier. They have suf-

[1]Joints are divisional planes, usually vertical or highly inclined, found in most rocks. There are in general at least two sets of planes nearly at right angles. There may be several sets. They result from both tension and from compression, and are only formed comparatively near the surface.

fered deformation only to the extent of being jointed and faulted. Except for recent mere surface decay they are practically as when they cooled and solidified. They have therefore never been deeply buried, as have the rocks which they cut, but, on the contrary, seem to have formed not far from the surface, since some of them contain numerous gas cavities. Hence the larger part of the early erosion of the region must have been effected before their appearance and yet after the intrusion of the earlier eruptives.

The region was yet a land area at the time and so continued for a space. The result of the long protracted erosion of the surface was to wear down the old mountains to mere stumps, producing a region of comparatively low altitude and quite insignificant relief. There were stream valleys with low divides between and numerous low, rounded hills, whose tops were apparently no more than a few hundred feet above the valley bottoms as a maximum.

This old land area was of much greater extent than the present Adirondack region, though that was apparently a more elevated part of the surface then, as now, of less relief however and lower altitude. While the last, finishing erosion touches were being given to the present Adirondack region, the sea had already begun to encroach on its borders, either because of a sinking of the land area or a rising of the sea level. This movement persisted also for a long time, and the region seems to have become an island in the midst of the sea, of constantly shrinking area as the waters rose around it, till finally they seem to have overtopped it, completely submerging the whole. It is possible that a small area may have persisted above sea level throughout, though, it is not likely, and in any case it was very small.

As each successive zone of the district passed beneath the sea, it ceased to suffer wear on its surface and began to receive deposit instead. The last portion of the present Adirondack region to pass beneath the sea would seem to have been the southern part. Since subsidence and deposition were proceeding at the same time, each new layer of deposit would encroach a little farther on the old land surface than the preceding one. In other words, they overlapped on its slopes. The subsidence of this old land area

seems to have been unequal on different sides, and also to have varied locally from place to place. Around most of the Adirondack region the first deposit laid down on the subsiding floor was one of coarse sand, often becoming a coarse gravel and with much feldspar sand at the base. It was deposited in shallow water in which was sufficiently strong current action to remove all fine mud. This formation is thickest on the northeast border of the

IDEAL SECTIONS ILLUSTRATING OVERLAP ON A SINKING LAND SURFACE, WITH MUCH EXAGGERATED VERTICAL SCALE

Fig. 1 Partial submergence; sand being deposited

Fig. 2 More complete submergence; limestone being deposited above the sand and also on the newly sunken land surface

Fig. 3 Almost complete submergence; shale depositing on the limestone and overlapping on the old land surface; the material being derived from some adjoining land area and brought in by currents.

Adirondacks, thinning thence both westward and to the south, and on the present southwest border was not deposited at all, and is not found within the map limits. The formation which succeeds it elsewhere is here found resting on the old land surface. A more detailed discussion of the reason for its absence here will appear on a later page. This formation is known as the Potsdam sandstone.

Subsidence continuing, the character of the deposit changed and the Potsdam is overlain by a variable thickness of dolomite and limestone beds, the former much predominating and nearly always containing some coarse sand which becomes very prominent in some layers. These rocks are peculiar, are not like ordinary open sea deposits, and the exact conditions under which

they accumulated are not thoroughly understood. The formation is called the Beekmantown limestone, but was known as the Calciferous formation till recently. It is also thickest in the northeastern Adirondacks and diminishes in thickness to the south and west, so that near the region under immediate consideration it also disappears and the next succeeding formation is found resting on the old land surface. Within the limits of the map the different layers of the Beekmantown formation successively overlap on the old surface, so that a thickness of over 400 feet at Little Falls has diminished to nearly or quite zero at the northern limit of the sheet. The overlap is beautifully shown around Diamond hill, a low mound of the old land surface, and will be later described in detail.

Following the Beekmantown, a marine, fossiliferous limestone, the Trenton formation, was deposited, with two thin lower members, the Lowville (Birdseye) and Black River limestones. This formation was very unequally deposited and shows a very rapid diminution in thickness toward the east in the restricted district under consideration. The Lowville is a pure, drab, thick bedded limestone in which calcite-filled tubes abound, and is the main quarry rock of the district. The Black River is a massive, black, brittle limestone usually, and is only here and there present in the district, the Trenton usually following the Lowville directly. The Trenton is thin bedded and usually gray, though with some black layers, and many of the beds are a mass of fossil shells.

Toward the close of the Trenton, fine muds began to be washed into the previously clear sea, at first intermittently, producing a series of alternating limestone and shale bands, later more continuously, giving rise to the fine muds of the Utica formation. The abundant clear water life departed and was replaced by a different and much sparser assemblage of forms. During the deposition of this formation it seems probable, from several lines of evidence, that the present Adirondack region was either wholly submerged or else so nearly so that only a few small islands were left protuding above the water. Here again the deposit

seems to have been thickest on the northeast, though the discrepancy is not so marked as in the case of the Potsdam and Beekmantown formations.

Following the deposition of the Utica formation, came a movement of disturbance and uplift of the region on the northeast and east. This apparently raised the present Champlain valley and northern Adirondack region above sea level, while the southern portion was not affected and remained submerged, so that the deposit of sediment continued on the south, though interrupted on the north. The successive Upper Silurian and Devonian rocks are now found outcropping in regular order as one goes south from the map limits, presenting their beveled edges to daylight. They all extended farther north originally. It would seem very probable, nay almost certain, that the higher Silurian rocks were deposited over the map limits and have since been removed by erosion. Quite possibly the Devonian also, in whole or in part, was so deposited.

There is a certain amount of evidence going to indicate that, during the late Silurian and early Devonian, the northern region became depressed again for a time and received deposit on its somewhat worn surface. But such deposit has been since wholly removed by erosion so far as northern New York is concerned, leaving us in entire ignorance as to its thickness, character and extent. Had these deposits been thick and of wide extent, however, we might reasonably hope to find remnants of them today, here and there. There is no evidence whatever that any rocks of later age than the Devonian have ever been deposited in, or about the Adirondack region, the recent Champlain clays and sands being of course excepted, and the evidence for the deposit of any of the Devonian is of the scantiest sort.

Probably coincident with the Taconic disturbance at the close of the Lower Silurian, occurred the last manifestation of igneous activity in the Adirondack region. This was mainly confined to the near vicinity of Lake Champlain, at least so far as the New York side is concerned. The igneous rocks of this date are now found in dikes, and occasional somewhat larger intrusive masses,

which cut and are therefore younger than all the rocks of the region, up to and including the Utica formation. Their date can not be fixed more definitely than this.

On the south also there is evidence of igneous action of later date than the deposition of the Utica formation. A few dikes are found cutting this and the older rocks as well, which may or may not be of the same age as those of the Champlain valley. They are of a somewhat different sort of rock from any found there, and this may possibly argue for a difference in age. None of these dikes have been noted within the map limits, but three outcrop along East Canada creek just east of those limits. In character they show a closer relationship with some igneous rocks

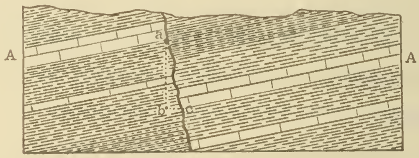

Figure 4

of apparent post-Devonian age which occur sparsely in central New York and they are probably related to them, rather than to the Champlain dikes.

Since the deposition of the Potsdam, Beekmantown, Trenton and Utica formations, the region has also suffered deformation, which has affected them as well as the older rocks. This later deformation has not been severe however. The rocks are but slightly folded, but are, on the other hand, considerably faulted and jointed.[1] This deformation period is of uncertain date except that it is later than the deposition of the rocks. Quite possibly

[1]A fault is produced by a sliding movement of the rocks on opposite sides of a fissure, with the result that the same rock stratum is higher on one side than on the other, as illustrated in the accompanying diagram [fig. 4]. The stratum AA has been dropped on the right side of the fault relative to its position on the left side. The distance *ac*, measured along the fault plane, is called its *displacement*, the vertical distance *ab*, that separates the two ends of the stratum, is called the *throw*, and the horizontal distance *bc* is the *heave* of the fault.

the first faulting of the region took place at the close of the Lower Silurian coincidently with the Taconic disturbance. But, even so, a fault once formed constitutes a line of weakness, along which further faulting is likely to occur whenever the region experiences further disturbance. It is by no means unlikely that repeated slips have taken place along the fault planes since they were first formed.

Two such faults, the Little Falls and the Dolgeville faults, are found within the limits of the map, and thence eastwardly faults cross the Mohawk valley repeatedly. The Little Falls break is the most westerly one which has been detected in the State so far as the writer is aware, though it is not at all unlikely that small ones, at least, will be brought to light farther west. The Little Falls fault has a throw of nearly or quite 800 feet at Little Falls, and is hence of very respectable magnitude. There is another fault on lower East Canada creek, just beyond the map limits to the east.

The Little Falls district has been nearly or quite continuously above sea level for a long time; since Devonian time in all probability and likely during a part of the Devonian also. The length of this period of time in years can be measured by no one with any degree of exactness, but a few million years are involved beyond any question, and quite likely a good many million. During this time its surface has been undergoing wear instead of receiving deposit. A considerable thickness of the rocks which mantled the surface as it rose above the sea has since disappeared, and the present surface rocks are such because of the removal of what originally lay above. Undoubtedly the shales of the Utica formation once covered the entire area. They have now disappeared from more than half of it. The Trenton has also been worn away from much of the surface, so has the Beekmantown, and the old floor of all these rocks has been eaten away somewhat in the localities where it is now exposed at the surface. Such later formations as may have been deposited have been wholly removed. We can imagine them as replaced in their old position, since we know their order and thickness from their outcrops to the south, but

we do not know at just what point to put the curb on our imagination.

The manner of progress of the wear on this land surface has depended on the rock characters and structures and must be left for later consideration. During this long time interval, the region has experienced changes of altitude, in part because of wear, in part because of up or down movements of the earth's crust. We are as yet far from being able to trace out these movements.

In times very recent comparatively, namely only some thousands of years ago, the district was covered by the ice sheet of the Glacial period. How long this condition persisted, how many times the ice came and went over the immediate region, we do not know. The advancing ice sheet removed the soil and loose rock from the surface and scoured away at the rock ledges beneath. The retreating ice sheet spread a heavy mantle of deposit over the surface. The melting ice gave rise to streams and lakes which rehandled some of the glacially deposited material. The larger preglacial topographic features were little changed and remain today substantially as they were before the onset of the ice. The minor irregularities of the surface were largely obliterated however, mainly by the deposits laid down during retreat. The stream valleys were filled nearly or quite to the brim, and the modern streams are largely in new courses therefore, specially the smaller ones. Unequal valley filling, and unequal deposit elsewhere left hollows in the surface in which lakes now nestle, lakes which had no existence before the advent of the ice. The Mohawk valley lowland is a preglacial feature, but the preglacial divide between the east and west flowing streams in this lowland seems to have been at Little Falls, and was certainly not at Rome, its present position. After the ice, on its last northerly retreat, had uncovered the Mohawk valley but still lay across that of the St Lawrence, the drainage of the Great lakes passed to the sea by way of the Mohawk, the eastern end of the lake in the Ontario basin being at Rome. The present Mohawk is an insignificant stream as compared with its great predecessor, which has of course left its mark on the valley.

The time since the departure of the ice has been so comparatively short, that the surface is substantially as the retreating glacier left it. During the retreat of the ice a slow movement of uplift was in progress in the region, and continued thereafter; in fact there are strong reasons for the belief that it even yet continues. Because of this change the Little Falls region stands today at an elevation exceeding by from 250 to 300 feet what it had when the last ice lay on it.

The streams of the region have either reexcavated their old valleys or are engaged in cutting new ones, but the time is not sufficiently long to have enabled them to make great progress in the latter task. Besides, the recent rising movement of the region has constantly lowered the level to which the streams can cut. Even the Mohawk is not down to base level at Little Falls and elsewhere. Away from the streams the glacial topography has been but little changed.

THE ROCKS

Pre-Cambrian rocks[1]

These ancient rocks are found at the surface over a large area occupying the northeast portion of the map, extending thence northward without a break through the entire Adirondack region. In addition, they appear at three disconnected localities, at Little Falls, Middleville, and at a spot locally known as the "Gulf," 2½ miles northeast of Little Falls.

The Little Falls and Middleville outliers. The pre-Cambrian rocks exposed at these two localities are identical, are quite homogeneous throughout, and are somewhat different in character from those exposed elsewhere. They are quite certainly old igneous rocks and belong to the syenite family of these rocks. They consist mainly of feldspar, always show some quartz, usually from 5% to 15% of the rock in quantity, and usually have only a small content of dark colored minerals, magnetite, hornblende, pyroxene and black mica. These minerals form a granu-

[1] A more detailed and technical description of these rocks will be given in the closing pages of this report.

lar mosaic in which are set feldspar crystals of varying size, whose glittering cleavage faces, on freshly broken surfaces, form the most noticeable characteristic of the rock. At Middleville these are very abundant and large, often reaching an inch and more in length, and the rock is much the coarsest syenite that has been found anywhere in the Adirondack region. In fact, it very strongly resembles in appearance much of the igneous rock called anorthosite, which has wide extent in the eastern Adirondacks. Both are composed mainly of feldspar, but the feldspar is of widely different character in the two. That of the anorthosite is apt to show striations, looking like fine ruled, parallel scratches, on the bright cleavage faces, but such striations do not appear on the syenite feldspar. The two differ much in chemical composition also.

The syenite at Little Falls is more widely and much better exposed than at Middleville, is by no means so coarse, varies more in character from place to place, and in part shows no large feldspars whatever. As shown along the Little Falls and Dolgeville Railroad, it was described in a previous report to the state geologist.[1] South of the Mohawk it is more homogeneous and more usually porphyritic than on the north side.[2] The westerly exposures, in and about the city, show considerable red, fine grained, granitic rock cutting the syenite.

This syenite has undergone extensive metamorphism, so that it has been rendered thoroughly gneissoid, and the finer grained portion of the original rock has been mostly, or wholly, recrystallized. The large feldspars also have been diminished in size by the breaking away of fragments from their exteriors. In general the Little Falls rock is much finer grained and vastly more gneissoid than that at Middleville. In places at Little Falls the large feldspars themselves have been completely crushed to a mass of fragments, and drawn out into lens-shaped patches, around which the foliation curves, as it does also around the uncrushed, large feldspars.

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[1] N. Y. State Mus. 20th An. Rep't, p.r83.

[2] A porphyritic igneous rock is one which shows more or less numerous crystals, surrounded by more finely crystalline, or even stony or glassy rock material.

C. S. Prosser, photo.

View of the cliff of pre-Cambrian syenite at Little Falls, looking west

Since these are small outliers and consist practically wholly of syenite, they can furnish no decisive evidence of the age of the syenite as compared with that of the other pre-Cambrian rocks. It has been stated that the Grenville rocks are closely involved with apparent igneous rocks which seem to have been either contemporaneous with them or to have been intruded into them not long after their deposition. Also that at a later date there was a time of great igneous activity in the region, when huge masses of molten rock were intruded into the Grenville rocks; and that at a third and much later time there was a further renewal of igneous activity, though in a minor degree. The writer's disposition is to regard the syenite under discussion as dating from the second of these periods, and as of much the same age as the the great syenite, anorthosite and gabbro masses of the central and eastern Adirondack region, but it should be emphasized that there is no decisive evidence in proof of this view. These two small areas are likely connected underneath and represent portions of the surface of the same mass, and it certainly represents a different intrusion from those in the heart of the woods, though regarded as belonging to the same group of intrusions.

Diabase dike. The only representative of the third igneous period which has been discovered within the map limits, is a huge dike of the rock known as diabase, which is exposed about a half mile east of the Little Falls depot along the Dolgeville Railroad. The rock is black and fine grained, with many half inch, porphyritic feldspars, of a general greenish gray, dull appearance because of alteration. Near the edges of the dike the rock becomes very black and dense and of stony texture, because of more rapid cooling and solidification there, due to the chilling effect of the walls. The dike is at least 120 feet in width, an unusually large size for these Adirondack dikes.

Grenville rocks. In the main pre-Cambrian exposures within the map limits, rocks which are of apparent sedimentary origin, and hence classed as of Grenville age, play an important part. The extreme metamorphism which they have suffered has produced complete recrystallization, with consequent disappearance

of all traces of the original structures which characterize the sedimentary rocks. The argument for their sedimentary origin rests on their composition, mineralogic and chemical, and on their frequent variations in composition, beds of different original character having produced differing metamorphic rocks, whose comparatively sharp junctions look like old bedding planes.

The most characteristic rocks of the Grenville series are the crystalline limestones, but these have not been found within the map limits. A single large boulder of impure crystalline limestone was noted on the surface of the heavy moraine which covers the district occupying the extreme north-central part of the map. As it is a soft and quite easily destroyed rock, these limestone boulders commonly indicate a parent ledge near at hand, here probably to the north, not far beyond the map limits.

In the absence of limestone, the rocks regarded as characteristically Grenville comprise a series of light colored, often white gneisses, very rich in quartz, interbanded with less quartzose rocks of darker color, and often with a very respectable percentage of black minerals, hornblende, black mica and magnetite. Both rocks contain, often in abundance, garnets of somewhat unusual color, a much lighter red than ordinary and with a rather pink tinge. These are more conspicuous in the dark rocks in general, but the light colored ones are seldom without them. They are commonly of about pinhead size but often run larger, specially in the darker rocks, those with diameters of from ⅛ to ¼ inch being often quite numerous, and even larger ones are to be found.

Another mineral which is very characteristic of these rocks and strongly indicative of their sedimentary origin, is graphite (black lead). Shining, metallic looking scales of this mineral occur frequently in the darker rocks, usually of sufficient size to be made out by the unaided eye.

Another characteristic mineral, this time confined mainly to the light colored rocks and only visible under the microscope, is sillimanite.

As has been said, the light colored rocks consist almost wholly of quartz and feldspar and are rich in quartz. Their composition

would indicate that originally they were sandstones, generally more or less shaly. In many of them the quartz is now found in thin, regular leaves separated by very finely granular feldspar, and such "leaf gneisses," as Dr F. D. Adams of the Canadian Survey has happily styled them, are a very conspicuous feature of the Grenville rocks. However, the severe metamorphism to which most of the pre-Cambrian rocks have been subjected has recrystalized much of their quartz in the leaf form, both in those of igneous as well as in those of sedimentary origin, so that this character can not be regarded as in any sense indicative of origin. It is naturally best exhibited by rocks rich in quartz, and some rocks which were likely granites originally show it in great perfection.

The darker colored rocks would seem to have been shales and calcareous shales originally. They must have contained a small amount of carbonaceous matter, very possibly of organic origin, now metamorphosed to graphite. Many ordinary shales and limestones contain carbonaceous matter, so that the supposition is a very natural one.

These Grenville rocks are very like rocks which Kemp has recently described from Warren and Washington counties, to the eastward, where they also occur in abundance, and where limestone is relatively scarce. From the standpoint of one who is familiar with but one of the two districts and necessarily depending on descriptions for a knowledge of the other, the rocks would seem identical in the two areas, and not unlikely the whole pre-Cambrian fringe on the south side of the Adirondacks will be found to be characterized by abundant Grenville rocks with a scarcity of limestone.

Probable igneous rocks associated with the Grenville. At most of the Grenville exposures of any extent, rocks which are regarded as igneous are found mingled with them. They are always thoroughly gneissoid and are interbanded with the old sediments. They are thought to represent old dikes and sheets of igneous rock, possibly surface flows also, which were formed during, or not long after the deposition of the sediments, and

which have been recrystallized and stretched out into rude parallelism with the sedimentary beds as a result of severe metamorphism.

Though of somewhat variable nature, they present three main types:

1 Red gneisses which have the mineralogy of granites, and are thought to have corresponding chemical composition also, though they have not been analyzed. They are usually fine grained and with quartz of a pronounced leaf type.

2 Black, hornblende gneisses, sometimes with pyroxene also and usually with black mica (biotite), which have the composition of gabbros or diabases.

3 Greenish gray gneisses, which have somewhat the color and appearance of very gneissoid varieties of the syenite previously described, and are very difficult to distinguish from them when occurring alone. They are commonly very quartzose, more so than the usual syenite, and very distinctly of the "leaf gneiss" type. They are very like the red gneisses of the first type under the microscope, have the mineralogy of granites, or of quartz syenites, and are regarded as igneous rocks. Their possible relationship with the Little Falls syenite is an exceedingly difficult problem, not as yet satisfactorily solved, though they are hesitatingly regarded as distinct and as older.

Though all these rocks are usually found interbanded with the Grenville sediments, so that there can be little doubt as to their close association, they may occur elsewhere unaccompanied by the sedimentaries, or with these in very minor quantity, and such areas have been given a separate coloration on the map, though the distinction is not a sharp one, and there is some question as to its wisdom.

Syenite gneiss. There is a considerable area shown in the northeastern part of the map where the rock is of the same sort throughout. The exposures are all in the woods and of the unsatisfactory sort that obtain there. The rock is thoroughly gneissoid, of a greenish color and weathers rapidly to a dingy brown. Most of the exposures show nothing but the brown rock, though usually

freshly broken surfaces will show at least patches of the green. The grain is usually quite fine, but the quartz is coarser than the other constituents and tends often to the "leaf" type, though but rudely so. In places a few larger feldspars show also and appear like small examples of porphyritic feldspars. The rock is prevailingly of feldspar, and feldspar of an acid type. It is quite quartzose, that mineral making from 15% to 20% of the rock on the average with a usual range of from 10% to 30%. Pyroxenes are the usual dark colored constituents, though both hornblende and biotite mica also occur. Without going into detail at this point suffice it to say that the rock has the precise mineralogy of an augite syenite, the same mineralogy as the rock at Little Falls and Middleville, and the same as the great mid-Adirondack syenite masses. It differs from them in being in general somewhat more quartzose, in being everywhere thoroughly gneissoid, and in the lack of porphyritic feldspars. It is however not to be in any way distinguished from some varieties of the rock in the other exposures. On the other hand, it has nearly, if not quite, as strong a resemblance to the greenish gneisses (3) just previously described.

Mixed rocks about the syenite. A large part of the pre-Cambrian area of the sheet shows rocks which are very like the syenite rocks and are thought to represent phases of them, but which are inextricably intermingled with smaller masses of undoubted Grenville rocks. The syenitic rocks predominate, though they are not of the normal type, but the Grenville rocks are in considerable force, and the relations between the two are wholly obscure. It was found impossible to separate the two in mapping on this scale, and therefore the complex as a whole is given a separate coloration on the map. Since the rocks seem to pass into the syenites on the one hand, and into belts in which the Grenville sediments preponderate on the other, the mapping of boundaries must, however, be a wholly arbitrary matter.

A very mixed lot of rocks is found in this belt as mapped, and with frequent changes from one sort to another. The most abundant type of all is a greenish gneiss, weathering brown.

which is richer in biotite, hornblende and pyroxene than the usual syenite. Metamorphism has concentrated these minerals along certain planes, producing a marked gneissoid structure, and a rock varying from green to black in general color. Where thus enriched by these minerals the rock approaches more nearly to a gabbro in composition, otherwise it is a syenite, though often very quartzose. With the increase in the quartz percentage the color often changes with facility from green to red and back again, just such a color change as is often seen in the great Adirondack masses of syenite. Bands of very basic feldspar, hornblende, biotite gneisses occur frequently with the others, and the whole series is cut by a multitude of small veins of quartz and pegmatite. Rocks like these appear in a multitude of exposures. All have the mineralogy of igneous rocks and are believed to be such.

Along with these a rock repeatedly occurs which resembles somewhat the green and black gneiss of the above, but contains garnets numerously also. It has the mineralogy of a rather basic igneous rock, neither a gabbro nor a syenite however, but of a rock intermediate between them and known as monzonite. It passes on the one hand into the syenite gneisses and on the other into the darker colored gneisses, often with graphite, of the Grenville series, the lighter colored gneisses appearing with these at times also. The whole series is perplexing and uncertain. The rocks differ considerably from the red, black and green gneisses previously described and regarded as igneous rocks of Grenville age. A possible, and perhaps the simplest explanation of the whole is that it is a sort of border belt between the syenite and the Grenville rocks, in which these last were all cut up by the syenite intrusion and in which they now occur as patches. Many contact rocks were formed and the whole subsequently was severely metamorphosed.

There still remains the question of the relationship of this syenite to that at Little Falls and Middleville, and to it the writer is unable to give any definite answer. If they are equivalent, it is strange that the pronounced porphyritic character of the rock of the two outliers should have so utterly disappeared in the main mass. Yet it may be legitimately argued that the porphyritic

texture is usually of local development in deep seated igneous rocks, that much of the rock at Little Falls lacks it and is thoroughly gneissoid, hence presenting an intermediate stage between the rock at Middleville and that of the main mass, and that in the great syenite masses of the central Adirondacks the bulk of the rock is not porphyritic, and the porphyritic development is local; also these are, at least in part, demonstrably of considerably younger age than the Grenville rocks.

Moreover, as has been stated, this syenite is almost equally hard to distinguish from the greenish gneiss of syenitic composition found so closely associated with the Grenville sedimentaries, and the granitic and gabbroic gneisses that accompany them. While this greenish gneiss is regarded as an igneous rock, it seems quite certain that its age association with the sedimentaries is close, as is also that of the accompanying granitic and gabbroic gneiss. It is also true of these latter that they are certainly much older than the gabbros and some granites which occur in the mid-Adirondack region, and it would seem therefore that the same might well be true of the syenite also. The green gneiss is regarded as being of this earlier age, so that there seem to be syenite rocks of at least two different ages in the Adirondack pre-Cambrian. But the writer is in doubt with regard to the syenite mass of the northeast part of the map, though disposed to regard it provisionally as belonging to the earlier period and to correlate it with the green gneisses of the Grenville. In regard to the rock at Little Falls and Middleville, he is also in doubt, though here with a disposition to refer to the later period, and to correlate with the later syenite of the central Adirondack region. The whole matter is one of great difficulty, and no decisive evidence for either view has yet been forthcoming anywhere.

Pre-Cambrian outlier northeast of Little Falls. There is exposed here a gray gneiss with a slight greenish tinge. The exposure is very small and shows but the one sort of rock. It is in the main a quartz feldspar rock, not more than 5% of other minerals being present, mostly magnetite, biotite, and a decomposed mineral which was likely a pyroxene. Quartz makes some 20% of the rock.

From 20% to 25% of the feldspar is oligoclase and the remainder is anorthoclase. The composition is that of a rather acid quartz syenite, and the rock is provisionally classed with the green gneisses associated with the Grenville rocks.

Paleozoic rocks

Potsdam sandstone. Though it has been sometimes held that this formation is present in a small way in the district, the writer found nothing that would warrant its mapping as a lithologic formation distinct from the Beekmantown. At the base the Beekmantown is often more sandy than usual and even pebbly, sometimes a thin shale band creeps in as at Little Falls, and sometimes a thin, disintegration conglomerate or breccia band, composed mainly of fragments of the underlying rock, is locally found. But these phenomena are precisely what would be expected, as an old land surface sank beneath sea level and began to receive deposit. These lower layers vary greatly in character from place to place, always are somewhat calcareous and usually are prevailingly so, and seem to have nothing in common with the coarse, pure quartz sands of the Potsdam formation. Furthermore, beds of this character are not confined to the base of the formation but equally sandy, sometimes pebbly, beds are found here and there at various horizons. Moreover, since the Beekmantown formation overlaps on the pre-Cambrian, the formation thins going north from the Mohawk, and hence successively higher and higher beds become basal. The small area near Salisbury, which Darton has mapped as Potsdam is, though basal, at an horizon at least 200 feet above the bottom of the formation as shown at Little Falls. The same characters run through several layers in the distinct overlap of the formation at Diamond hill, the ordinary character being resumed at a little distance from the spot, and the rock is still somewhat calcareous and has not the lithologic character of the Potsdam.[1] Nor does the basal bed at Little Falls appear to represent the real base of the formation, deep well records to the west seeming to indicate an increased thickness in that direction, under

[1] N. Y. State Geol. 14th An. Rep't 1894. Map at p.33.

cover of the younger rocks. These are at a greater distance from the pre-Cambrian outcrops than are the exposures at Little Falls, and this increased thickness is no doubt due to overlap, as is the diminished thickness in the other direction. It is therefore held that there is nothing which can be mapped as a formation, corresponding to the Potsdam, in this portion of the Mohawk valley, but that the Beekmantown rests everywhere on the pre-Cambrian, overlapping on its surface. It is by no means impossible that the Potsdam may come in below, farther away from the present pre-Cambrian edge of outcrop, but there is yet no decisive evidence that this is so.

It is also possible that the base of the Beekmantown, as exposed at Little Falls, may be of Cambrian age. This can only be determined by fossils, and as yet these have not been forthcoming in sufficient number and variety to settle the question.

Beekmantown formation.[1] The Beekmantown rocks are best exposed about Little Falls, Middleville and Diamond hill, though presenting numerous outcrops elsewhere. In the main, they consist of a gray, more or less sandy dolomite. Occasional layers are very sandy and sometimes even pebbly, and such layers are not confined to the base but may appear at any horizon. Some sandy layers show bright, glittering cleavage faces when broken. Such layers are found in the formation all about the Adirondack region,

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[1]The paleozoic rocks of the Mohawk valley have been much studied and described, and the writer's work has added little to our knowledge of them except for some structural details. The main purpose of the work was the study of the pre-Cambrian rocks; and, since the prosecution of this work required considerable traversing of the rest of the area, it seemed a pity not to grasp the opportunity to delimit all formation boundaries on the accurate base of the recently published new map. The more important papers touching on the stratigraphy of the immediate district are as follows:

Clarke, J. M. U. S. N. Y. Handbook 15. p.60-63
Darton, N. H. N. Y. State Geol. 13th An. Rep't. 1893. 1:409-29
——— N. Y. State Geol. 14th An. Rep't. 1894. p.33-53
Hall, James. N. Y. State Geol. 5th An. Rep't. 1885. p.8-10
Prosser, C. S. Am. Geol. 25:131-62
——— N. Y. State Mus. Bul. 34, p.469-70
Prosser & Cumings. N. Y. State Geol. 15th An. Rep't. 1895. p.632-37
Vanuxem, L. Geol. N. Y. 3d Dist. 1842.

and the writer has elsewhere shown that the appearance is due to a secondary calcite cement deposited between the sand grains, so that they become as it were incorporated in calcite crystals whose cleavage gives the characteristic appearance to the broken rocks.[1]

Many of the beds of the formation, in the Little Falls district, are full of small, drusy cavities which are in general coated with minute dolomite crystals, sometimes with calcite as well. In these cavities are often one or more quartz crystals, generally small and water clear, though sometimes of quite large size, the latter usually full of inclusions. These crystals have long been known and have made the district a famous one to the mineralogist. They are locally known as diamonds and have given the name to Diamond hill, where they are very abundant, as they are also about Middleville. In addition, the cavities often contain much of a black, carbonaceous material, sometimes nearly filling the cavity, sometimes as films on which the dolomite crystals rest, sometimes running into cracks of the rock, and sometimes occurring as inclusions in the quartz crystals in a finely divided state. This material has heretofore been called anthracite, behaves precisely like that substance when heated and must have the same approximate chemical composition, though with somewhat different physical properties. From the standpoint of origin it would seem to be certainly an asphalt derivative. It was the first substance to form in the drusy cavities and was followed by the dolomite crystallization, though the two seem to have overlapped somewhat. Both the quartz and the calcite were formed after the dolomite. The writer observed no instance of a cavity in which quartz and calcite were both present; so that it can not be stated which of the two was formed first.

Near or at the summit of the Beekmantown formation, is a very cherty layer, becoming locally a pure mass of chert, which is sometimes red in color. This cherty layer often has a mineralized appearance, due to abundant, small, bluish green spots which have some resemblance to green copper carbonate (malachite).

[1] N. Y. State Geol. 16th An. Rep't. 1896. p.19.

C. S. Prosser, photo.

The Beekmantown formation at Little Falls. Boyer quarry in sandy dolomite, forming the basal portion of the formation; a shale band shows at the base, and the pre-Cambrian lies just beneath.

There is however no copper at all in the rock and the green spots appear to be constituted of glauconite.[1]

A certain amount of mineralization is sometimes to be noted in some of the layers of the formation, zinc blende (sphalerite), galena, pyrite and chalcopyrite all occurring, though always in small quantity.

The Beekmantown formation is overlain by a pure gray limestone known as the Lowville. The Chazy limestone lies at this horizon along Lake Champlain, but does not appear in the Mohawk valley. Its absence is due to a cessation of deposition in the Mohawk region and an uplift which probably raised the district slightly above sea level, sufficiently to stop deposition, but not sufficiently to permit of much wear. This uplift likely involved all of the State except the Champlain region, and persisted through the latter part of Beekmantown time and throughout the Chazy. Then subsidence was renewed, though but slowly at first.[2]

In the Little Falls district the upper boundary of the Beekmantown is not everywhere sharp, a grading into the Lowville through a series of passage beds of intermediate character being often seen, as was first noted by Prosser.[3] These beds are of no great thickness, 8 feet being the maximum noted by the writer, along White creek nearly 3 miles north of Middleville. Prosser measured 11 feet at Newport on West Canada creek not far west of the map limits. These beds are of too slight thickness and too interrupted to map separately on a map of this scale, and have been therefore included with the Beekmantown, the base of the Lowville being made at the first pure limestone stratum.

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[1]Glauconite is a mineral of varying composition, but essentially a silicate of iron and potash. In sedimentary formations it has often a close association with the skeletons of minute organisms; and, since the chert is likely of organic origin, the association is a natural one. It is not at all indicative of any mineral content of value in the bed.

[2]The Chazy formation is over 800 feet thick toward the lower end of Lake Champlain, and diminishes rapidly in thickness to the south and west till it wholly pinches out. Moreover the entire Lower Paleozoic rock series is thickest on the northeast, diminishing thence west and south, so that more profound subsidence appears to have characterized the former region throughout.

[3]N. Y. State Geol. 15th An. Rept. 1895. p.627-31.

Just east of Middleville the upper layer of the Beekmantown is a coarse conglomerate, consisting of pebbles of quartz and chert in a matrix of quartz sand grains, cemented by calcite. This conglomerate was noted at but the one locality, but elsewhere a very sandy, sometimes slightly pebbly, layer, often full of pyrite (marcasite) is seen at this horizon, instead of the usual chert layer.

The best exposures of the Beekmantown are those at Little Falls, where, on the south side of the river, nearly every foot of the 450 feet thickness of the formation may be seen. The exposures about Middleville are also very good, though the thickness has dwindled to about 200 feet, and a section so nearly continuous can not be seen. The contact on the pre-Cambrian is shown in the West Shore railroad cut at Little Falls, and also in the banks of Spruce creek at Diamond hill [see pl.3]. It formerly showed, in the Boyer quarry at Little Falls, and even yet almost does so. All along the line of contact on both sides of the river at Little Falls the contact just escapes showing.

The Spruce creek locality has been noted by both Vanuxem and Darton.[1] The pre-Cambrian rocks there are garnetiferous Grenville gneisses with quartz veins, with some basic layers, and some rusty weathering beds full of pyrite. One of the latter is at the contact for the slight length of its exposure, and plate 3 illustrates its rapidity of weathering as compared with the overlying Beekmantown. The more resistant quartz veins project into the overlying Beekmantown layer, so that specimens of almost solid quartz can be broken out from it. Otherwise it, and the next two layers, have an arkose character, and the lower of the two is quite pebbly. They are also full of pyrite locally. While their materials are somewhat waterworn they consist merely of more or less weathered fragments of the underlying rocks, the resulting rock being mainly a product of weathering rather than of sedimentation. But these beds grade rapidly into the ordinary Beekmantown above, are themselves somewhat calcareous, and make a perfectly logical basal layer for the formation. In plate

[1]Geol. N. Y. 3d Dist. p.255.
N. Y. State Geol. 13th An. Rep't 1893. p.417.

H. P. Cushing, photo.

Contact of Beekmantown on pre-Cambrian in Spruce creek at Diamond hill. The upper pre-Cambrian decays readily, and the actual contact is visible for only a few feet and can not be clearly brought out in a photograph. The pre-Cambrian shows best at the right.

N. H. Darton, photo.

Beekmantown-pre-Cambrian contact in West Shore Railroad cut at Little Falls. The plate shows the pebbly character of the lower Beekmantown layer, but this is a not infrequent character in the district. The pre-Cambrian is augite syenite.

4 the contact on the south side of the river at Little Falls is excellently shown. The lower layer is quite pebbly and extra sandy, as it is at Spruce creek, but the basal layer at Spruce creek, because of overlap, is from 150 to 200 feet above this pebbly layer at Little Falls. It is unlikely that this latter represents the actual base of the formation and a reference to the Potsdam because of lithologic character seems wholly uncalled for in view of the above facts.

The contact with the overlying Lowville limestone is shown at numerous localities within the map limits, and at many others shows within a few feet. A number of the tributary creeks into West Canada creek, both above and below Middleville, expose this contact. Some of the creeks into the Mohawk from the south also expose it, and it is well shown about Ingham Mills. A comparison of these different contacts brings out some interesting things in regard to the presence or absence of the passage beds, and variations in thickness of the Lowville down to complete absence, going to show great local variation in deposition conditions at this horizon, and indicating, when coupled with the occurrence of the local conglomerate at the summit of the Beekmantown, a probable slight unconformity.

Trenton formation. The Trenton formation as mapped is made to include the Lowville and Black river limestone stages as well as the Trenton limestone, since in the district these are mainly too thin and too variable to be mapped separately from the Trenton without exaggeration. They lie below the Trenton and can in general be assumed to represent the basal 5 to 15 feet of that formation as mapped.

Lowville limestone. The different beds of this formation are very similar, consisting of gray, brittle, pure limestone layers in which are more or less numerous long, tubular cavities filled with white, crystalline calcite, which are exceedingly characteristic of the formation. Other fossils are very rare, though Leperditia, a fossil crustacean shell looking like the half of a small bean, occurs occasionally. It is the purest limestone in the district, is fairly thick bedded, and has therefore been considerably quarried for building stone for local use.

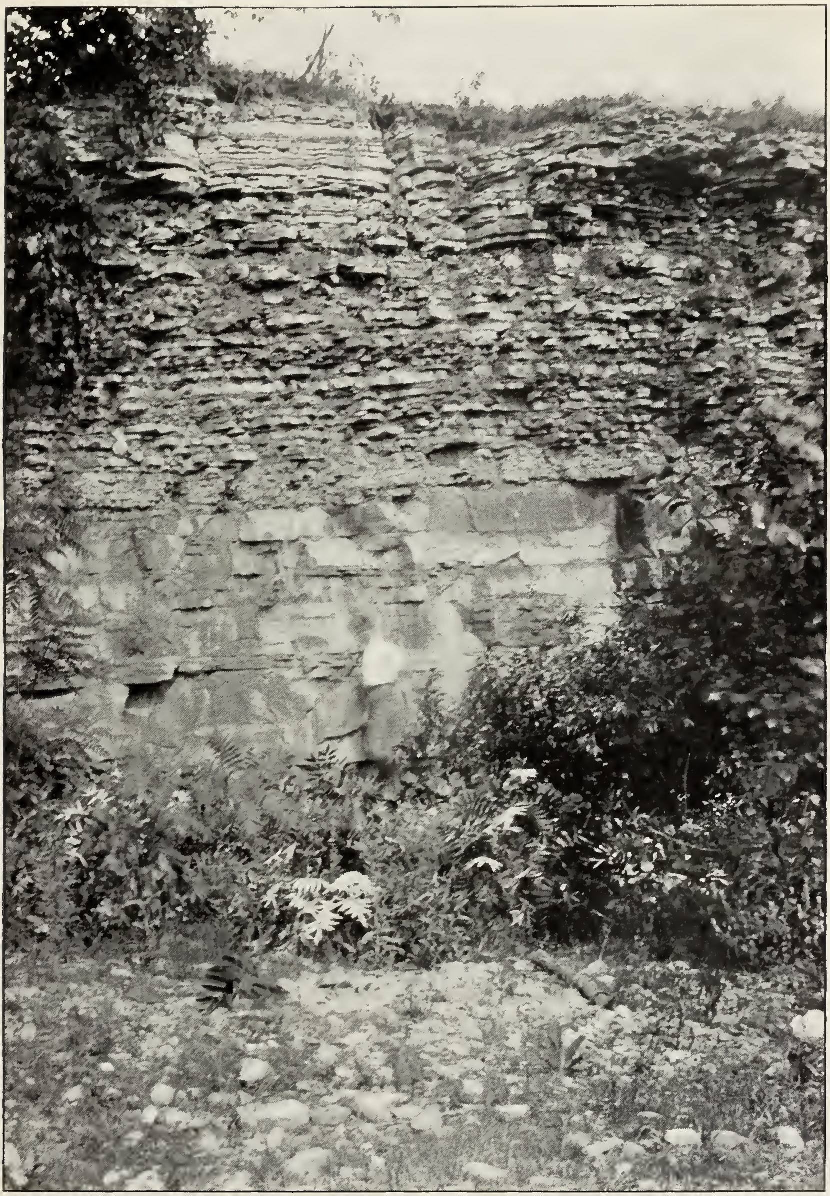
About Middleville the formation ranges from 15 to 21 feet in thickness, the 6 to 8 feet of passage beds being excluded. To the westward it is still thicker, as shown by Prosser about Newport. South from Middleville it quickly dwindles to an average thickness of about 10 feet, and this it keeps all along the Mohawk to the east limits of the map, ranging from 8 to 12 feet thick. About Ingham Mills, Prosser has measured one thickness of a little more than, and another of a little less than, 10 feet.

The upper boundary of the formation is commonly sharply defined, the overlying Black river or Trenton being of quite different character and passage beds being lacking. Occasionally a layer with the lithologic character of the Lowville recurs a few feet above the summit of the main formation, as has been shown by Prosser at Ingham Mills, but this is exceptional.

About Diamond hill and thence northward, the Lowville shows nowhere in outcrop, and in places the Beekmantown and Trenton occur sufficiently close together to show that, if the Lowville occurs here at all, it must be under 5 feet thick. In the Mohawk valley to the eastward, beyond the map limits, it disappears entirely for an interval.

Black river limestone. Normally this formation consists of thick bedded, black, brittle limestone which underlies the Trenton directly. In the Little Falls district it is mostly absent, the Trenton directly following the Lowville. So far as the writer is aware, Prosser was the first to show its presence in the district, he reporting the 5 foot thickness which is shown at Ingham Mills.[1] But just north of the mills, at the second bridge, the old quarry face shows 10 feet of Black river limestone, with the Lowville below and Trenton above, in a vertical 25 foot section [see pl.5]. It consists of 4 to 8 inch layers of black, brittle, blocky limestone separated by shale partings of approximately equal thickness. The limestone bands are like the Black river in lithologic character and in stratigraphic position, and contain fossils rather numerously, so that it will be easy for the paleontologist to determine whether or not it is the normal Black river fauna, as it seems to the writer to be.

[1] N. Y. State Mus. Bul. 34, p.469.



H. P. Cushing, photo.

Quarry face at bridge north of Ingham's Mills, showing 10 feet of Lowville (Birdseye) limestone at base, followed by 8 feet of thin black limestone bands with shale partings, of Black river age, and capped by 5 feet of Trenton limestone.

A thickness of 4 feet of black limestone with shale partings, quite like that at Ingham Mills, is exposed ½ mile to the southeast at the brook and road crossing near the east edge of the map. The Trenton appears directly above, but the full thickness and the Lowville below do not show.

Away from the vicinity of Ingham Mills the formation has been noted at but one locality within the map limits. By the road from Diamond hill to Gray, nearly 4 miles beyond, and slightly to the west of north of Diamond hill, the Lowville limestone is shown and capped by a 3 foot thickness of solid, black limestone with the Black river character and fauna. The summit does not show.

All the other contacts within the map limits, and they are many, show the Trenton resting directly on the Lowville, with the exception of one a mile north of Middleville, which discloses a thickness of 1 foot of black, calcareous shale between the two. We have therefore nearly as marked evidence of irregularity and interruption of deposition above the Lowville as there is below. There is to be added to this also as significant, the variation in thickness of the Lowville itself, and the fact that the nearly complete lack of a marine fauna in it would likely indicate local and restricted deposition conditions, rather than those of the open sea. The marine fauna would certainly have been preserved in the rock had it been there.

Trenton limestone. The larger part of the thickness of the Trenton within the map limits is constituted of a gray, thin bedded, semicrystalline limestone, often a mass of fossils or of fossil fragments, locally called shell rock. With this are layers of dark blue limestone, sometimes rather massive but oftener thin, and with a shaly tendency. These are sometimes very full of fossils also, but usually contain them much more sparingly than do the gray beds. In general the gray beds are more prominent in the lower, and the dark blue in the upper part of the formation.

Upward, the gray layers die out entirely, and the limestones are succeeded by a considerable thickness of alternate limestone and shale bands of blue black color, which form a lithologic transition

zone between the Trenton limestone below and the Utica shale above. The limestone bands range from 3 to 18 inches in thickness, and the rock is hard and brittle and quite like the dark blue beds of the Trenton. The shale partings are of blue black shale quite like the Utica above. There is a diminution in amount of limestone and increase in that of shale upward, but on the whole a pretty constant and rapid alternation of the two, continuing through a vertical interval which varies from 25 to 100 feet in thickness, thickest on the west and thinnest on the east.

Lithologically these beds are no more Trenton than they are Utica but are distinctly intermediate in character, and no more to be classed with the one formation than with the other. There is some little shale in the Trenton below, and some rather calcareous beds in the Utica above, but not in sufficient quantity to characterize the formation in either case. Whether the contained fossil fauna would ally the transition beds more distinctly with the underlying or the overlying formation, the writer is not qualified to determine, though strongly of the opinion that the fauna is equally a transition one. Apparently these beds have been classed with the Utica heretofore.

Most of the limestone bands of these passage beds are fossiliferous only sparingly or not at all, but some contain fossils in considerable numbers, and search in the shales will nearly always bring them to light. In the basal portion are some very fossiliferous, black limestone bands which seem unmistakably Trenton.

The best exposures of the Trenton limestone within the map limits are shown in the brooks tributary to West Canada creek from Middleville south. Stony creek, coming in from the east at the county house, shows the best section, comprising the upper portion of the Beekmantown, the entire Lowville which is 15 feet thick here, followed by an unbroken section of 100 feet of Trenton. For ½ mile the fall of the creek is very rapid and most of the section is comprised within that limit. Above, the stream is flowing down the dip for the most part, and the rock thickness passed through in the remaining ¾ mile of exposures is not great. The section ends at or near the base of the passage beds, and

above are no rock exposures for 2 miles, when Utica shale appears at an altitude 300 feet higher.

The two brooks which come down from the west, the one just above, and the other just below the county house, show the upper part of the section and the contact between the passage beds and the Utica, though their sections are much more interrupted by breaks than is that of Stony creek. The combined section of the three creeks shows a thickness of about 100 feet of Trenton and an equal thickness of the passage beds, or 200 feet in all between the Lowville and the Utica.

There are also most excellent Trenton exposures along East Canada creek, the best being just above Ingham Mills, where the full thickness is shown in a cliff face which is unfortunately most inaccessible even at low water, since the full volume of the stream hugs that bank. A mile farther up stream it again shows magnificently, being brought up by a low fold, but here the base is not reached and the summit is cut off by a fault which crosses the creek.[1] Up the little brook, above the Black river limestone locality already referred to southeast of Ingham Mills, an uninterrupted thickness of nearly or quite 40 feet of Trenton appears, overlying the Black river. The Trenton hereabouts is nearly or quite 50 feet thick, and the passage beds have a nearly equal thickness. This is somewhat less than half the thickness shown along West Canada creek, and the many exposures elsewhere indicate a progressive thinning of the formation eastward.

From 13 to 15 miles northwest from Middleville are the noted Trenton falls and gorge along West Canada creek. Here the Trenton has a measured thickness of 270 feet, with neither the base nor summit exposed, so that the true thickness is an unknown, but likely small amount in excess of that figure.[2] The same distance to the southeast from Ingham Mills, down the Mohawk at Canajoharie, the thickness has diminished to 17 feet, [plate 10], is lithologically rather like the rocks here classed as passage beds, and the lower part of the Utica seems to have some-

[1] Clarke, J. M. U. S. N. Y. Handbook 15, p.61.

[2] Prosser. N. Y. State Geol. 15th An. Rept. 1895, p.626.

what the same character.[1] So it is evident that the thinning of the Trenton eastward across the territory included in the map sheet, is only a local exhibition of a more widely extended feature.

Ripple marks in the Trenton. A mile above the mouth of the creek which empties into West Canada from the east 2 miles above Middleville is an interesting exhibition of ripple marks, interesting because of their comparative rarity in limestone formations. The Trenton section up this creek is a very interesting and complete one. The ripple-marked horizon is about 100 feet above the base of the Trenton and in slaty limestones which approach the passage beds in character. The stratum has a slight westerly dip and the creek flows down the dip for several rods, so that the rippled surface is widely exposed. The crests of the ripples are from 9 to 15 inches apart, so that they are considerably broader than the usual ripple marks in sandstones, and the troughs are depressed from 1 to 3 inches below the crests. They run nearly at right angles to the course of the stream, which is thus flowing down a gently inclined, corrugated surface. There results from this a number of little, local eddies in the water, which are strongest in the lowest sags of the troughs. Here the water is beaten up into foam, forming globular masses up to 6 inches in diameter, which rotate in the eddying water and give a very striking appearance to the stream. Varying dip brings this layer to daylight again some 50 rods farther up stream. Not far beneath is a knobby, black limestone layer, full of nodules of chert, containing much pyrite (marcasite), and holding a great number of specimens of a single species of fossil (Orthoceras).

Utica shale. This formation consists throughout of black, or blue black, somewhat carbonaceous, fine mud shale. It is mostly very thin splitting (or fissile), this being specially true above. In the lower portion more solid bands are not infrequent, and the shale is usually somewhat calcareous, thin bands of slaty limestone being of frequent occurrence in the basal portion, though

[1] Prosser. *Op cit* p.638-40.

not constituting the marked feature of the formation that they do in the passage beds.

The overlying Lorraine shales of the Hudson group were not noted anywhere within the map limits, and it is thought that their horizon is nowhere reached. North of the Mohawk only the lower portion of the Utica is exposed, little beyond the lower 200 feet, if any. South of the river, much higher beds are found, and the altitude of the hills in Danube and German Flats at the south line of the map is nearly or quite sufficient to reach the Lorraine horizon. But these hills are heavily drift-covered, and so deeply so that the actual rock exposures beneath are at a horizon considerably below what the altitude of the hill summits would indicate. The highest beds actually seen are in the town of Danube and on the southern edge of the map. The black, slaty shales outcropping here are 500 feet in altitude above the base of the formation which, together with the upper layers of the passage beds, outcrops near Indian Castle. Since, in addition, the former are 2 miles west of the latter, and since the dips are low to the southwest, these beds must be somewhat over 500 feet above the base of the formation and are likely not far from its summit. The actual summit of the hill on the side of which this outcrop appears, is 200 feet higher, but it is a moraine knob on which the drift is so heavy that all rock is deeply buried beneath. The thickness of Utica shale shown in the Campbell well near Utica is given as 710 feet by Mr C. D. Walcott.[1] It may be thicker or thinner here but is certainly close to 600 feet, exclusive of the passage beds and with the summit not reached.

STRUCTURAL GEOLOGY

Dip

The Paleozoic rocks were originally deposited as nearly horizontal sheets, though with a probable slight inclination to the south or southwest. Oscillations of level in the region since that time have given the rocks a somewhat greater tilt in the same direction, the rocks have been slightly folded also, causing loca-

[1]Am. Ass'n Adv. Sci. Proc. 36:211-12.

variations from the general direction of dip, and they have also been faulted, producing again local variations, which are most marked near the fault lines.

The general direction of dip in the immediate district is to the southwest. The amount is variable though seldom exceeding 5°, and the general average is much less than this. The steeper southwest dips are counteracted by occasional changes of dip to the northwest, because of slight folding. The average dip can only be obtained by bringing large distances into consideration. For example, just east of Middleville the summit of the Beekmantown (the most convenient horizon for the purpose) lies at an altitude of 800 feet above sea level. In the deep well at Ilion, approximately 10 miles distant in a direction somewhat to the west of south, the same horizon was reached at a depth of 630 feet below the mouth of the well, or 225 feet below sea level, an altitude 1025 feet lower than at Middleville and amounting to a fall of somewhat over 100 feet to the mile. This represents a dip not greatly in excess of 1° in this direction. It is quite possible that this is not along the line of greatest dip, that running somewhat more to the westward, but it is exceedingly unlikely that the general dip exceeds 2°.

In the near vicinity of faults steep dips have often been produced by the drag of the rock masses on each side of the fault plane as they have moved past one another during the faulting, the layers being bent upward on the downthrow, and downward on the upthrow side of the fault. The less massive and rigid rocks are, the more they yield to this drag, and hence its effects are in general more pronounced on shales. The Utica shales have thus been given very steep dips near the fault lines of the district, being found with inclinations of 50° to 60° and even more. Such steeply dipping shales show magnificently in the east bank of East Canada creek, just below the Dolgeville power house [pl.8]. They are also well shown in some of the small creeks which cross the Little Falls fault line to the east and northeast of Little Falls.

Folds

Since the rocks dip to the south and west, it follows that they rise in altitude going north. In mapping the formation boundaries it was soon discovered that the rise was not regular, but that a given rock horizon would remain at approximately the same altitude for a distance, then rise rather suddenly to a greater altitude, which was then held for a time, to be followed by another sudden rise. The sudden rises are indicative of rather steep (5°) southerly dips, followed by very flat dips which may be either southerly or northerly. These changes are plainly shown in the topography also, as will appear later. They are most marked in the near vicinity of the faults and are perhaps somewhat involved with them, but they are by no means confined to such situation.

About Middleville the dips bring out the fact that there has been a doming up of the rocks into a low arch there, in the center of which erosion has cut down to the pre-Cambrian. Southward from Middleville the Beekmantown-Lowville contact drops in altitude at the rate of about 100 feet to the mile. Northward from Middleville the northwest dips carry it down in that direction also, though much less rapidly, only about 20 feet to the mile. Three or four miles to the north, these are again replaced by the steeper southwest dips, and the contact rises in altitude. Here is therefore an instance of precisely the same sort of gentle folding that is in evidence along the fault lines.

In East Canada creek the same sort of thing is well brought out. At Ingham Mills the Beekmantown is exposed in the creek bed, with the Lowville, Black river and Trenton above. Just north of Ingham a rather steep northwest dip sends the four formations in rapid succession below the creek level. Sixty rods farther north, changed dip brings the Trenton again to the surface, and it so continues to the fault line, forming a low arch, since the dip changes again to the northwest before the fault is reached.

So far as observed, the axes of all these folds trend from east and west to northeast and southwest and pitch to the west and

southwest. In nearly all cases the southern limb is steeper than the northern, the fold in East Canada creek just north of Ingham Mills being an exception.

In addition to these larger folds, small ones appear in many localities. These are best shown and most conspicuous in the Lowville limestone, though by no means confined to that formation. Such folds are beautifully exhibited in the creeks about Middleville, many of which flow down their westerly pitching sags. Plate 6 shows most excellently these slight folds as seen in the quarry in the Lowville limestone at Ingham Mills; but they show almost equally well in a great number of localities and seem as characteristic of the rocks hereabouts as are the larger folds.

Faults

The Little Falls fault is the most westerly of a series of large, north-south breaks which cross the Mohawk valley, and is the only great fault within the map limits. The Dolgeville fault is of a lower order of magnitude, though still a considerable break. The Manheim fault (of the same order as the Dolgeville) lies just outside the map limits to the east. The second fault at Little Falls is a small affair and likely simply a branch of the main fault, which is very irregular and certainly branches somewhat, to the northward of Little Falls. Three other quite insignificant faults have been detected by the writer, and quite likely others exist. It seems very unlikely that the Little Falls fault marks the westerly limit of faulting. White has in fact noted two faults in the Trenton Falls district in addition to the one noted by Vanuxem, and quite likely others will be forthcoming when detailed mapping is carried northwestward.[1]

Little Falls fault. This fault was long ago described by Vanuxem, and recently in more detail by Darton. The latter was without an accurate base map on which to plot his results, and also lacked our present knowledge of the thickness of the various formations of the district, which is so largely due to Prosser's ex-

[1]Vanuxem, L. Geol. N. Y. 3d Dist. p.51-54.
White, T. G. N. Y. Acad. Sci. Trans. 15:80-81.

H. P. Cushing, photo.

Folds in the Lowville (Birdseye) limestone at Ingham's Mills. The basal layer is of Beekmantown age and the thin upper layer is Trenton, the Black River being absent. The folds have a low pitch to the s. w. A similar photograph might be taken at numerous other localities in the district, the low folds being characteristic of the region.

cellent work. There is therefore much in the way of details to be added to his description.

South of the Mohawk the topography gives no aid in the location of the fault line, as is the case at, and north of, the river. It has been traced for only some 3 miles in this direction, though it ought to be traceable beyond the map limits provided rock outcrops are forthcoming in that direction. Where last seen, its throw is sufficiently large to guarantee that it must extend some distance farther south.

North of the river the fault can be followed with great accuracy for 3 miles, both as a topographic feature and because of abundant rock outcrops. The actual fault plane is indeed exposed at several localities. Beyond, the topography locates it for 4 miles more, though there is a great scarcity of rock exposures on the downthrow side. Still beyond, up to the point where it passes beyond the limits of the map, its position can not be accurately located, since outcrops wholly fail on the downthrow side, the drift covering is very heavy on both sides, and the topography gives little assistance. Darton has mapped it for some distance farther, but the writer has not been over the ground.

The fault plane approaches verticality, and the downthrow is to the east [*see* accompanying maps and sections]. Darton estimated the throw of the fault at 310 feet, which is accurate for the spot where the measurement was made, but the place proves to have been unfortunately chosen, as will shortly appear. Prosser's accurately measured section at Little Falls furnishes the necessary data for estimating the throw there. The pre-Cambrian rocks are at the surface west of, and the Utica shales east of the fault line. The entire Beekmantown and Trenton, approximating 550 feet in thickness, are thrown out. In addition, the pre-Cambrian rocks rise to 200 feet above the river level at the fault line, while the Utica shale is at the river level on the east side, so that this 200 feet must be added to the other, giving 750 feet. In addition again an unknown thickness of Utica shale must be added. The Utica is heavily dragged upward near the fault, and, to obtain the actual throw, it should be flattened out. Two miles east of the

fault plane, the upper portion of the Trenton-Utica passage beds is exposed near the mouth of Crum creek, at an elevation of 80 feet above the river, and on the south side, at Indian Castle, the same rocks show only 30 feet above the river level, with the Utica outcropping close at hand and only 20 feet higher up. The westerly dip would carry these rocks down to, and slightly below, the river level before reaching the fault line. Hence it is inferred that no great thickness of Utica shale, say 100 feet as a maximum, can be involved east of the fault line, and that therefore the throw of the fault at Little Falls is certainly as much as 750 feet, and lies somewhere between that figure and 850 feet.

South of the Mohawk, after climbing the hill, the Trenton and then the passage beds are at the surface on the west, and the Utica shales on the east of the fault. Since, however, the Utica is at the river level on the east side, since the altitude here is from 500 to 600 feet above the river, and since the dip is to the south about 100 feet to the mile, the horizon in the Utica must be in the neighborhood of from 650 to 700 feet above the base of the formation, so that the throw has not greatly diminished in this direction if it has at all.

The fault plane crosses the river with an approximately northeast and southwest trend. Within the first mile north of the river it swerves somewhat to the north, and then curves sharply westward through an angle of nearly 90°, continuing in this new direction for a mile, when it again swerves to the northward at a sharp angle. In this westwardly trending portion the fault is not a single sharp break as heretofore, but shows Utica shale on the downthrow, and Beekmantown rocks on the upthrow side, with a zone of much shattered Trenton between, having a varying breadth of from 100 to 300 yards; in other words, the fault is doubled through this part of its course with an intermediate shattered zone of no great breadth.

The accompanying section [fig. 5 *a*], made along the road which crosses the fault line midway in this part of its course, shows the usual conditions, though with less minor breakage than usual. Just to the west of the road in the fields, displaced blocks of the

Lowville and Trenton appear, close to the more southerly branch of the fault, with a nearly or quite vertical dip. Figure 5*b*, shows the conditions at this point. A few yards farther west there is exposed a rubble zone composed of broken up fragments of Beekmantown, Lowville and Trenton limestone, with an exposed width of 20 feet, which marks the fault plane of the south branch of the fault, the flat Beekmantown showing directly to the south, but no rock shows just to the north of the rubble zone.

The throw of the fault here can only be conjectured. The entire Trenton and passage beds are thrown out, together with

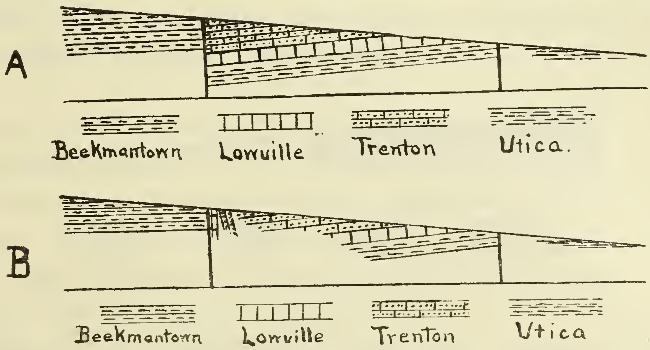


Fig. 5 Sections across the Little Falls fault. Scale, 75 yd=1 in.

unknown amounts of the Beekmantown and Utica. The exposed Beekmantown at the south is however very near the summit of the formation, so that no large amount of it is involved. On the dropped side the exposed Utica would also seem to be near the base of the formation, since the upper passage beds are exposed not far away. The throw would therefore seem not to exceed 300 feet here. This greatly diminished throw in a distance comparatively so short, coupled with the fact that still farther north the throw is approximately the same as at Little Falls, leads the writer to conjecture that quite likely the fault branches at the turn, and that this branch has remained undetected, owing to scarcity of outcrops. That the fault should suddenly diminish so greatly in magnitude, and then shortly reach again its former importance, might perhaps be brought about by its change in direction, but this would seem to be very unlikely.

At the second turn, where the fault swerves again to the north, a little brook crosses the fault line and exposes the very excellent section shown in figure 6, Utica shales, with gradually increasing dip due to drag, appear on the dropped side, the dip rising to 60° near the fault plane. Just at the fault a small block of black limestone like that of the passage beds appears with vertical dip, and then flat lying layers of the Trenton appear, beyond which nearly the full thickness of that formation and the overlying passage beds is shown. The throw here is even less than in the previous case, quite certainly under 300 feet, emphasizing the probable presence of an undetected branch fault. If such be not present, the throw of the fault has diminished two

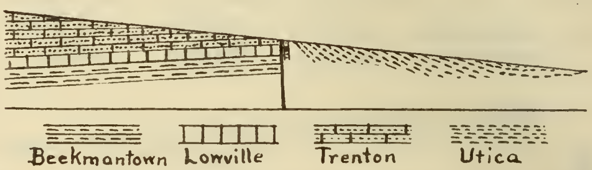


Fig. 6 Section across the Little Falls fault. Scale, 200 yd=1 in.

thirds in amount, and yet rapidly increases to the northward from this point up to its original size.

The trend of the small fault at Little Falls would carry it into the main fault at this corner, provided it extends so far. But the throw of this fault is very slight at best, so that it can not be traced beyond the river, and the junction is simply inferred.

Nearly 1 mile north of this locality a second fault appears, which seems clearly a branch of the main fault, though its actual point of union with that cannot be located. For a distance of a half mile (to the "Gulf" and a little beyond) the two faults can be traced, running nearly parallel for most of the distance, and giving rise to the apparent rock confusion at the "Gulf," which Darton seems to have interpreted as due to the depth of the stream cutting[1]. One of the sections of the structure section sheet map crosses the fault at this point and shows the writer's conception of the conditions. Darton's measurement of the throw

[1] N. Y. State Geol. 14th An. Rep't. 1894. p.37 and map opposite p.32.

of the fault (310 feet) was made here, and is accurate for the one fault, whose throw is just the thickness of the Beekmantown here, approximately 300 feet. But the real throw here is the combined throw of the two faults, and the second fault throws out the entire Trenton, the passage beds, and an unknown amount of the Utica, so that in the writer's judgment its throw is equal to, or exceeds that of the main fault, as from 100 to 200 feet of the Utica seem clearly to be involved. If that estimate be correct, the combined throw of the two faults here gives a total which does not fall far short of the throw of the single fault east of Little Falls.

One mile farther north the pre-Cambrian rocks appear at the surface from beneath the Beekmantown on the upthrow side of the fault, and thence northward are continuously at the surface on that side. The Utica is the surface rock on the other, but does not show in outcrop anywhere near the fault line. The more northerly of the sections of the structure section sheet crosses the fault line hereabout. The throw of the fault here is somewhat conjectural, since the amount of Utica involved is unknown. The Beekmantown has thinned to only about half the thickness present at Little Falls, but the Trenton and passage beds seem somewhat thicker here than there, though outcrops do not suffice for any precise measurement of their thickness. The horizon in the Utica would seem certainly higher than at Little Falls. It is thought that this, with the thicker Trenton, will largely make up for the diminished Beekmantown thickness, so that, while the throw here may be 100 feet less than at Little Falls, that is an outside limit.

All along this part of its course the absence of outcrops on the east side of the fault makes it impossible to determine whether the fault branches or consists of a single break, though in the absence of any evidence to the contrary the latter is regarded as most probable.

Dolgeville fault. This fault can be traced for only 1½ miles, beyond which its farther extent in both directions is concealed by heavy drift deposits. To the south it must soon disappear because

its throw is reduced to zero. Followed northward from its first point of appearance, its throw increases with unusual rapidity, as noted by Darton.[1] The last point of identification is at the High falls, below Dolgeville, beyond which it can not be traced because of utter lack of outcrops for several miles.

Where the fault crosses the creek, its most southerly point of exposure, the creek has a rock bottom, and the section furnishes interesting evidence of the manner in which the fault is dying out. The dips are rather high, from 30° to 60° on the downthrow side, and the layers have been beveled to an even surface by the cutting action of the stream, so that at low water the section shows mag-

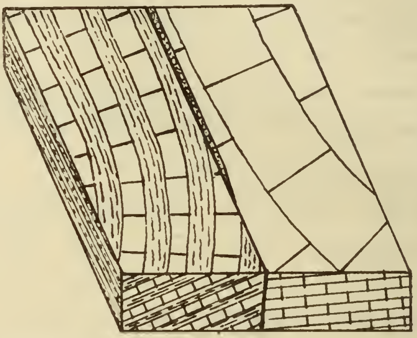
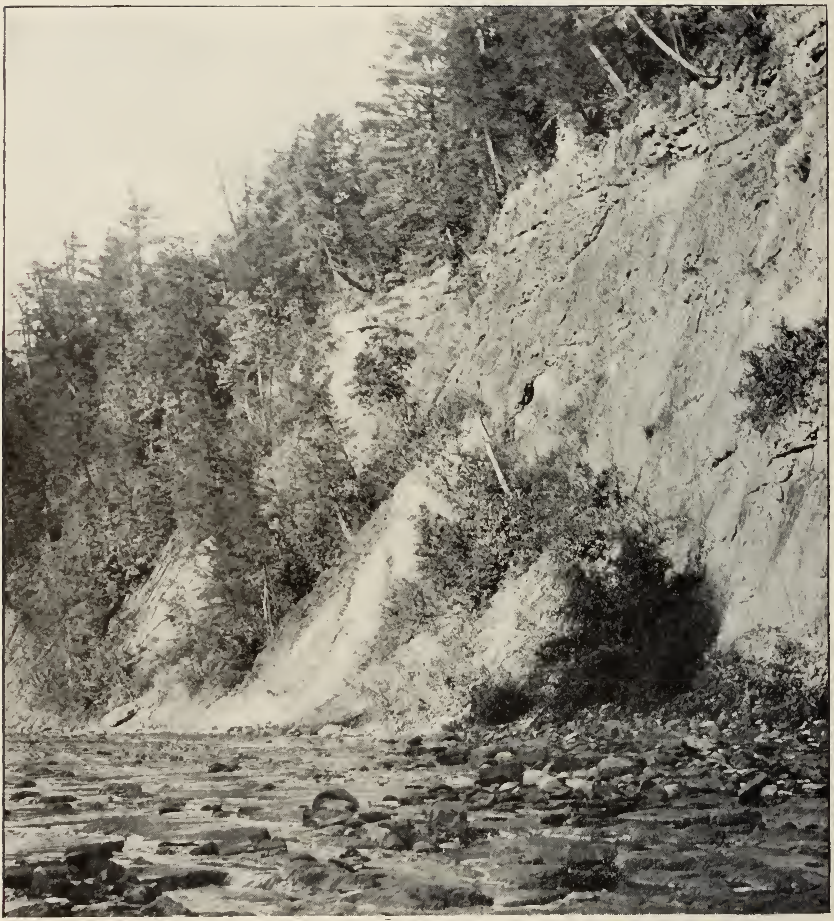


Fig. 7 Plan and section to illustrate the conditions where the Dolgeville fault crosses East Canada creek. Trenton limestone is at the surface on the east side, and the alternate shales and limestones of the passage beds on the west. The divergent strike brings lower beds in succession to the surface on the west, or downthrow side, and higher beds on the east side, with consequent diminution of throw.

nificently. Figure 7, though not an accurate scale drawing, reproduces the observed conditions quite faithfully. There is a breccia zone a few inches wide along the fault line. The spreading produced by swerving of the strike is most marked on the west side, which coupled with the high dip there, brings successively lower layers to the surface with some rapidity. The fault seems to pass into a monoclinal fold southward, which fades out in its turn, and this seems a step in the transition.

Some 50 rods north of this point another smaller fault appears in the east bank of the creek. It shows Utica shale on both sides and has but an insignificant throw. Judging by the

[1] Darton gives four sections across this fault, *op. cit.* p.41.



H. P. Cushing, photo.

The Dolgeville fault exposed in the bank of East Canada creek. At the right the fault is at the base of the vertical cliff, which consists entirely of Beekmantown layers, the Lowville capping not showing in the view. Over most of the cliff the fault breccia is still in place, so that the stratification shows only here and there. The fault plane is seen to diagonally ascend the cliff face from right to left, commencing at the dark bush and following the line of bushes. The sloping surfaces below are those of the updragged layers of Utica shale, whose stratification may be made out at the extreme left.

drag, it also throws to the west, as does the main fault, and it is likely a small branch of the latter. It would indicate that the dying out of the fault is probably produced in part by branching.

Between these two points a bend in the creek carries its east bank back against the fault plane, which here forms a nearly perpendicular cliff some 80 feet in hight, rising directly from the creek margin. The topographic map is not quite accurate here, so that it is impossible to properly show this feature upon it, an excessive bend and an incorrect course being required to bring the fault to the creek on the map as it stands. The fault plane continues at the margin for only a few yards, then runs diagonally up the cliff face, updragged Utica shale appearing at the base,

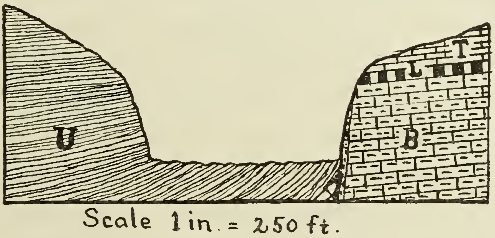


Fig. 8 Section across East Canada creek at the point where the Dolgeville fault forms the east bank. U=Utica shale, T=Trenton limestone, L=Lowville limestone and B=the Beekmantown beds. The fault breccia is also shown. The section crosses the east wall at the right in plate 6.

and running constantly higher, till it forms the entire hight of the cliff. The features are magnificently shown, but are unfortunately difficult to photograph satisfactorily, plate 7 showing them as well as it is possible to bring them out. Figure 8 gives a scale drawing of the section here. A fault breccia from 2 to 5 feet wide, consisting of a multitude of angular fragments of all sizes, in which Beekmantown material largely predominates, but with a considerable contribution from the Lowville and Trenton also, embedded in a black, fine grained matrix, which seems largely of Utica origin, occurs here. There is a layer of chert near the summit of the Beekmantown here, as elsewhere, and this has naturally been a large contributor to the breccia. It has been also largely impregnated with pyrite or marcasite, which forms at times nearly the entire matrix, and whose decomposition and oxidation

has blotched the cliff with iron stain. The summit layers of the Beekmantown are also much more pyritiferous than usual. The fault breccia still clings to much of the cliff face, and since the fault plane is nearly vertical, having only the slightest possible inclination westward, it appears much like a vertical dike along the cliff wall.

About 75 feet thickness of Beekmantown rocks is exposed in the cliff above the creek level, while lower Utica appears at that level on the opposite side of the fault; hence the throw comprises that thickness of the Beekmantown, the entire Trenton (inclusive of Lowville and Black river), from 40 to 50 feet thick hereabouts, and an unknown amount of the passage beds and lower Utica, of no great thickness however. The throw is therefore in the neighborhood of 150 feet, while $\frac{1}{4}$ mile to the south, where the fault crosses the creek it will not much exceed 25 feet.

From this point northward to the Dolgeville power plant, at the High falls, a distance of about a mile, the fault runs parallel with the creek and not far distant from it, with steeply updragged Utica shales forming the easterly wall of the gorge. These show beautifully at the power plant [pl. 8 and 9]. A short distance to the east is an old quarry in the Beekmantown at a level 140 feet above the creek bed below the fall. Moreover this is not the summit of the Beekmantown though the actual horizon is unknown. More than this thickness of this formation is therefore involved in the fault here, along with the entire Trenton and passage beds, and an unknown, but here considerable amount of the Utica, the throw here being certainly as much as 300 feet and likely more. The increase in throw has therefore been maintained northward, though apparently at a somewhat less rapid rate than at first.

Beyond this point the creek swerves away from the fault, which becomes wholly lost in heavily drift-filled country.

One mile above Dolgeville a small fault shows in East Canada creek just at the second big bend beyond the village. The fault is in the Utica shales though the associated thin limestone bands indicate that the horizon is not far above the passage beds. The

H. P. Cushing, photo.

Utica shale, east bank of East Canada creek, at the power house near Dolgeville. The steep dip is due to updrag of the Dolgeville fault. It shows best in the left center. The tipping has made one of the joint sets horizontal, and these horizontal joints simulate bedding on the right. The joints are therefore older than the faults.

H. P. Cushing, photo.

Fall in East Canada creek at the power house near Dolgeville. The cliff shown in plate 8 forms the right wall of the gorge just below the fall. The shale here is therefore a little farther away from the fault. The dip still shows the effect of drag, and in increasing amount from left to right, becoming suddenly much steeper at the extreme right.

fault is a small one of unknown throw, at the crest of a low anticlinal fold, with sharp drag on the east side. It is a fair sample of the insignificant faults of the vicinity.

All the Mohawk valley faults, so far as known are normal faults with nearly vertical hade. Nearly all of them downthrow to the east, the only exceptions to this rule known in the region being two of the faults which occur here, the Dolgeville, and the small fault at Little Falls. These both downthrow to the west.

Foliation

The excessive metamorphism to which the pre-Cambrian rocks were early subjected has produced in them a foliated structure, in a varying degree of perfection; varying not only with change in the character of the rock, but from place to place in the same rock. Igneous and aqueous rocks are alike foliated, though commonly the latter are much more distinctly so than the former. The old bedding planes of the aqueous rocks are so obliterated that they have not been made out and it can not be stated what relationship, if any, they bear to the foliation planes. Of the old igneous rocks the syenite at Middleville shows the least foliation of any. The corresponding rock at Little Falls is however excessively foliated, though varying much in amount from place to place. The syenites and granites to the northward are thoroughly gneissoid.

The foliation planes of the district have a nearly east and west strike. Of the very large number of readings taken on them about 65% lie between n. 70° e. and n. 90° e., and the larger part of the remainder do not exceed these limits by more than 10°. Locally however there is considerable variation, largely due to folding.

The dips of the foliation planes are now to the north, now to the south, showing that they have been folded. Sometimes changes in dip direction are frequent showing small folds, but in the main the folding is on a large scale. In the majority of cases the dips are gentle, not exceeding 20°, but there are many instances of steeper dips, even reaching 90°, and in many places the rocks are excessively and minutely folded and crumpled.

Where the strike swerves to the northwest from its usual direction, the dip is usually found to be to the north, and a corresponding change to the northeast is accompanied by a south dip. Usually a change in dip from north to south is accompanied by a swerving of the strike as above noted, though, where the dips are gentle, the change is apt to be very slight. But, so far as it goes, the evidence indicates a general pitch of the folds to the east.

Joints

Pre-Cambrian rocks. The pre-Cambrian rocks are invariably much jointed. The larger number of the joints are vertical, or nearly so, though they may depart from the perpendicular by varying amounts up to as much as 30°. It is an exceedingly difficult matter to reduce these joints to any system, since they show a surprising lack of uniformity in direction. Most individual exposures show vertical joints in only two directions, though sometimes a third, and rarely a fourth is added. While these two directions are tolerably constant locally, they vary widely from place to place. A large number of readings have been taken on these joints, and, when it is considered that the area on the map occupied by these rocks is only some 50 square miles, the great variation that they show in direction is surprising, and it seems almost futile to attempt to reduce them to any system. To illustrate, 129 readings on these joints were so selected as to represent rather uniformly the pre-Cambrian area, the readings rejected being some of those from places where, because of frequent outcrops, many more than the average number were available. These were plotted as shown in figure 9. In general, readings can not be taken closer than within 5°; and all others have been plotted at the nearest 5° point (33° being made 35° and so on). On this basis there are 36 possible directions of joint planes, and out of these 31 actually occur. Were the joint planes regular in direction, this would imply a great number of joint systems, but the diagram is itself prima facie evidence that they are not regular. Moreover at most outcrops but two systems are to be seen, and also at most outcrops one or both sets are actually seen to be very

irregular, and that in two ways; first, the joints are often observed to curve, and second, the various planes of the same system are often far from parallel. Hence the usual imperfect exposures in the woods, which form the larger number of the pre-Cambrian exposures, and which are apt to show only one or two planes of a set, are likely to give widely varying results.

In many of the pre-Cambrian exposures the two sets of joints shown are, the one parallel to, and the other at right angles to the strike of the rocks. The other exposures show joints which do not conform to the strike, one set making an angle of from 15°

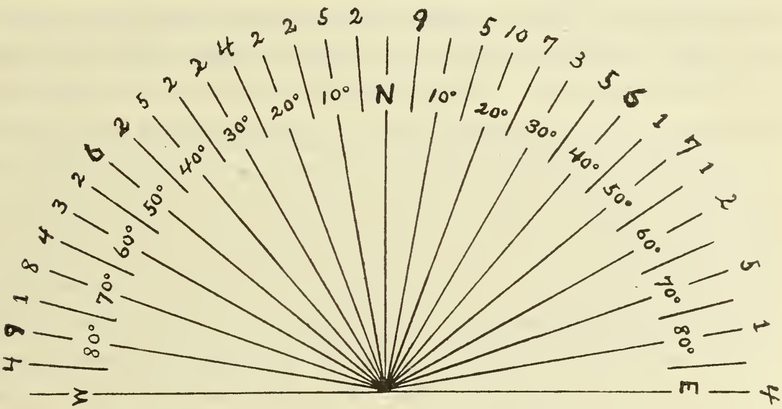


Fig. 9 Diagram of 129 readings on joints in the pre-Cambrian rocks. The inner row of figures represents the points of the compass, in degrees from the true north. The outer row gives the number of readings on joints for each compass direction.

to 45° with it. Sometimes this is brought about by a swerving of the strike while the joints hold their direction, as is the case at Little Falls; at other times it occurs when the strike has remained constant in direction. This latter fact seems to the writer to imply perhaps two groups of rather irregular joints; and the diagram, figure 9, would seem to bear out such an interpretation. Bearing in mind that the curving of the joints causes considerable latitude in the direction of a given set, the diagram shows that the larger number of readings lies between n. 5° e. and n. 25° e. and the next larger number between n. 65° w. and n. 85° w., the two being approximately at right angles. A less well defined group is possibly indicated in the northeast and northwest directions.

The joints in the pre-Cambrian rocks are vastly better shown at Little Falls than at any other locality on the sheet, the steep joint cliffs in the long railway cuts there being familiar to everyone. There are two conspicuous sets of vertical joints here which are at, or nearly at, right angles to each other (the readings show an angle varying between 70° and 90°). Both sets vary somewhat in direction; one gives readings of from n. 70° w. to n. 90° w., the other from n. 20° e. to n. 35° e. There is however a third set to n. 10° w. or thereabouts, which is locally the most conspicuous of all. The strike of the foliation planes at Little Falls varies between n. 60° w. and n. 90° w., being sometimes parallel with, and sometimes making an angle as high as 40° with the n. 50°-70° w. joint set. This plainly indicates that the variations in direction of joints and foliation are independent of one another.

In addition to the vertical joints, there are at least two sets of much less steeply inclined joints. These are in the majority of cases dip joints, following closely the direction and inclination of the foliation planes. They are most numerous and pronounced in the Grenville gneisses, but occur frequently in the igneous rocks as well, being specially noteworthy in the granitic gneisses associated with the Grenville rocks. The other set is at right angles to the first in regard to both strike and dip, and is not so well marked. Both seem to be compression joints, and the fact that the strike of the second set is at right angles to the foliation strike suggests that the two sets are probably due to compressive forces acting at different times and in opposite directions.

Paleozoic rocks. In these the compression joints are lacking, but the vertical (tension) joints are abundantly developed, and when plotted show the same wide variation in direction found in the pre-Cambrian rocks, so that it is not certain that any set is present in the latter which is not also found in the former. There are however more readings in the direction n. 70° e. than in any other, giving this direction much greater importance than in the pre-Cambrian rocks.

Since the Paleozoic rocks are folded only in the most gentle fashion, the joints have likely no connection with the folding.

Their great irregularity may perhaps indicate that desiccation was a prominent factor in their production. Of these rocks the Utica shales show the most numerous and sharpest joints, and they are least in evidence and most irregular in the Beekmantown rocks. Three sets are often present in the Utica, because of which the harder layers break out into triangular blocks.

Though the fact can not be deduced from a comparison of the readings, it is quite certain that the pre-Cambrian rocks were jointed before the deposition of the paleozoics. The prevailing east-west trend of the diabase dikes, in the regions where these occur, would seem demonstrative of a set of joints having that direction, and suggestive of the probability that that was the only good set.

SOME OSCILLATIONS OF LEVEL DURING THE EARLY PALEOZOIC

Certain matters which are in no sense novel call for consideration here. The main propositions have been already advanced by others. But the detailed study of the Little Falls district has brought out evidence of the verity of certain notions long held which is new, and also the facts can perhaps be marshaled more convincingly than has been the case hitherto.

Paleozoic overlap on the pre-Cambrian floor

It has already been stated that in pre-Paleozoic times the Adirondack region was a dry land area for a vast length of time, and that a subsidence commenced during the Cambrian, in virtue of which the sea slowly encroached on the region from all sides, that it became an island in the midst of the sea, and that by the close of the Lower Silurian the entire region was either entirely submerged or else so nearly so that but little of it still protruded above the waves; that, as it sank, each succeeding rock formation deposited on the floor of the encroaching sea, would extend farther in on the old land surface than the previous one, so that each would be in turn found resting on that surface in going toward its center, constituting what is called overlap. This is in the main the ordinary conception of this portion of the history of the region, and has been specially elaborated by Mr C. D. Wal-

cott, on various occasions. Since Paleozoic deposition ceased in the region, and it became anew a land area, it has been decapitated by the prolonged erosion which has followed. The Paleozic cover has been entirely worn away from the heart of the Adirondacks, these rocks now appearing as a fringe about the district. In the past they extended farther in than they do now; the erosion of the future will remove them from districts which they now cover, increasing the extent of the area in which the older rocks form the surface exposures. The conditions along the edge of the fringe, so far as they differ, depend not only on

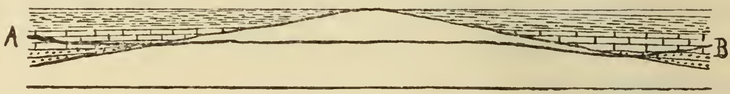


Fig. 10 A reproduction of fig. 3. to illustrate the supposed condition in the Adirondack region at the close of the Utica period. Subsequent erosion has worn off the region down to the line AB, reexposing the pre-Cambrian rocks over a wide area, and leaving the Paleozoic rocks confined to the flanks of the region.

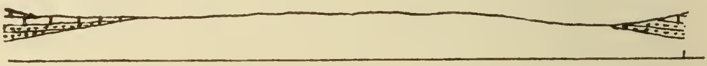


Fig. 11 The region after the wearing away of the upper portion, the line AB of the previous figure forming the surface. Erosion has cut more deeply on the right hand side than on the left. On the right the basal sandstone is exposed, lying uncomformably on the old surface, with the overlying limestone appearing farther to the right. On the left the limestone appears lying on the old surface, erosion having nowhere cut deeply enough to expose the underlying sandstone.

possible differences in the conditions of original deposition on different sides of the region, but also on the depth to which erosion has since cut. If we should assume that the Potsdam, Beekmantown, Trenton and Utica formations were successively deposited all about the Adirondacks, progressively overlapping toward the center of the district, then it is theoretically quite possible that we might today find the Potsdam resting on the pre-Cambrian here, the Beekmantown there, and the Trenton or Utica elsewhere, for the reason that more rock had been removed by erosion in the former case than in those following, that in them erosion had not yet cut deeply enough to bring the edge of the Potsdam to daylight from underneath the overlying and overlapping Beekmantown [fig. 10, 11].

Within the map limits the Potsdam sandstone is wholly absent, the Beekmantown resting on the old, pre-Cambrian surface. The

Potsdam may be absent because of overlap, in which case it should be present to the south and west, under cover of the Beekmantown and still later rocks which are at the surface in those directions; or it may be absent because of nondeposition, the subsidence of the region hereabout not having commenced till the close of the Cambrian; or, lastly, it may be absent as a recognizable lithologic formation comparable with the Potsdam sandstone, for the reason that no sand was brought into the upper Cambrian sea here by currents or by streams, a limestone or a shale or both having been deposited instead. The latter alternative can only be determined by the fossils, and in their absence it is impossible to affirm that the basal portion of the Beekmantown may not be of Cambrian age, though it is not probable.

Such evidence as has been brought to light up to the present, is not sufficient to enable us to pronounce affirmatively in favor of any of the above suppositions. One or the other of them must represent the actual facts of the case. Such evidence as is available comes from the deep wells which have been drilled to the west and northwest of the district. Of these there may be specially mentioned the Remington well at Ilion, less than 3 miles west of Herkimer; the Globe mills well at Utica and the Campbell well 3 miles west of Utica; the Rome Brass & Copper Co. well at Rome; and finally the wells in Pulaski and Orwell, Oswego co.[1] These wells were all drilled with churn drills, and the mashed rock fragments produced by this method of drilling are often difficult of proper determination. Had we diamond drill cores from them, the evidence would be all that could be asked. These wells have all begun in, or above, the Utica shale horizon, and have penetrated the entire rock thickness down to, and a varying amount into, the pre-Cambrian. They have gone through the entire rock series here in question, but the fragmental

[1] Prosser, C. S. Am. Geol. 25:131–44.

——— Geol. Soc. Am. Bul. 4:100–1.

Walcott, C. D. Am. Ass'n Adv. Sci. Proc. 36:211–12.

Orton, Edward. N. Y. State Mus. Bul. 30, p.426–50.

samples saved do not suffice properly to identify the rocks. The confusion which exists is in the proper discrimination of the Potsdam from the Beekmantown on the one hand, and from the pre-Cambrian on the other. The basal Beekmantown is often very sandy; and the light colored pre-Cambrian gneisses will furnish a rock powder exceedingly difficult to distinguish from the Potsdam except by the most searching microscopic examination, possibly not even by that. Thus the earlier interpretations of the Globe and Campbell wells assigned from 300 to 400 feet of the rock passed through to the Potsdam. Prosser's later study of the Rome well led him to the belief that the Potsdam was not present there, the Beekmantown resting on the pre-Cambrian, with a total thickness of 475 feet. But the basal 275 feet of the rock referred to the Beekmantown seems not at all calcareous, so that its reference to the Beekmantown is somewhat problematic. Lithologically it certainly does not belong there. On the other hand, as Prosser points out, it is very probable that much, if not all of the rock referred to the Potsdam in the two Utica wells may in reality be pre-Cambrian.[1]

As might reasonably be expected, the Ilion well exhibits a section very like the surface section at Little Falls. The Beekmantown is a little thicker, but it shows calcareous matter down to its very base, just as it does at Little Falls. Since Ilion and Little Falls show such similar sections, though 9 miles apart, it is exceed-

[1] Through the kindness of Professor Cushing, I have had the opportunity of reading the above remarks concerning the Beekmantown limestone in the Rome well. Data obtained after the preparation of my paper on "Gas-well Sections in the Upper Mohawk Valley and Central New York" leads me to accept fully Professor Cushing's conclusions. Of the 475 feet referred to the Calciferous [Beekmantown] formation in the Rome well (*loc. cit.* p.139, 140, 143), I would now refer the upper 190 feet, from 1085 to 1275 feet in depth, to the Beekmantown limestone. The lower 285 feet, from 1275 to 1560 feet, are apparently not calcareous and are composed mainly of quartz sand. It is not improbable that part of this thickness, and perhaps all, belongs in the Potsdam sandstone; but I am inclined to think that it is a difficult matter to say where the line between the Beekmantown and Potsdam formations shall be drawn.

C. S. Prosser

Mar. 10, 1902

ingly improbable that, in going the 12 miles farther west to Utica, any such thickness of Potsdam as 300 feet could have crept in in the interval. On the other hand, the great thickness of noncalcareous layers which Prosser has included in the Beekmantown in the Rome well, would seem to the writer to indicate that some Potsdam might be present, both at Rome and at Utica. The reference of 285 feet thickness of noncalcareous sandstones to the Beekmantown seems to the writer hardly justifiable. Orton has classed the 475 feet of rock between the Trenton and the pre-Cambrian in the Rome well as Potsdam and Beekmantown (Calciferous), without attempting to draw any line between the two, and this would seem all that we may do safely at present, though there is unquestionably some justification for Prosser's argument, based on the rock thickness, 475 feet being closely the thickness of the Beekmantown at Ilion and Little Falls. If it be all Beekmantown at Rome, the formation has undergone a pronounced lithologic change in the interval.

The Oswego county wells, though many miles distant to the northwest (Pulaski is nearly 40 miles from Utica in that direction), seem to give significant evidence in this connection. Prof. Orton reports 156 feet of sandstone which he calls Potsdam, in the Central Square well between the limestones and the pre-Cambrian; also a 50 foot thickness of similar sandstone in the Parish well. In the Pulaski wells he reports from 40 to 90 feet of rock thickness between the Beekmantown and the pre-Cambrian, the general section being

Beekmantown	
Greenish sand	10–40 feet
Black limestone	20–40 feet
Greenish sand	5–10 feet
Pre-Cambrian	

In the Stillwater well there are similar sands with limestone lying on the pre-Cambrian, the limestone being 6 feet thick, with 18 feet of calcareous sandstone below and 25 feet of green and white sandstone above. Fossil fragments occur in the limestone

chips brought up from this stratum, from which its Upper Cambrian age was determined.

These records seem to demonstrate the presence of deposits of Upper Cambrian age in Oswego county, under cover of the newer rocks and at a distance of some 20 miles from the nearest surface pre-Cambrian outcrops to the eastward. They have not been reported in surface outcrops along the pre-Cambrian boundary, the overlying Silurian limestones seeming to lie directly on the pre-Cambrian there. Apparently we have here direct evidence of overlap, and also evidence of a considerable change in the lithologic character of the Upper Cambrian, it being no longer typical Potsdam sandstone. Nor is the formation here of any great thickness, as compared with the Potsdam sandstone of the St Lawrence and Champlain valleys. But in answer to this last, it might be argued that the diminished thickness here was due to overlap, and that sufficiently deep wells located some few miles to the westward of the Oswego county wells might show a greatly increased thickness of Upper Cambrian rocks, and with our present knowledge this argument could not be gainsaid.

In summing up, it may be said that we have in Oswego county good evidence of the presence of the Upper Cambrian horizon, and that it is absent along the pre-Cambrian boundary because of overlap. Along the line from Rome to Little Falls the evidence is not decisive as to the presence of the Upper Cambrian, nor is there any special indication of thickening in the whole series of deposits between the Trenton and the pre-Cambrian, as should be the case were the conditions those of overlap. But there is the possibility that the Potsdam is represented in the Rome and Utica wells, though it is only a possibility and does not enable us to decide definitely whether the Upper Cambrian was ever deposited anywhere within the limits of the upper Mohawk valley or not.

Beekmantown overlap. The uncertainty which exists in regard to conditions hereabout in Potsdam times, ceases with the beginning of Beekmantown deposition. The evidence of Beekmantown overlap is clear and decisive.

The Beekmantown at Little Falls is 450 feet thick. Northward from there, following first the fault line and then the Beekmantown–pre-Cambrian boundary, the thickness gradually diminishes. At Diamond hill it has shrunk to about 100 feet. Beyond that point exposures are not sufficient to determine the amount absolutely, since the base nowhere outcrops. The last Beekmantown exposures seen are located nearly 2 miles south of the north boundary of the map sheet. While the thickness here can only be inferred, it can be safely said that it can not exceed 40 feet, and is likely not over half that amount.

One mile farther to the northwest Trenton limestone and pre-Cambrian gneisses are exposed sufficiently close to one another to almost preclude the possibility of the presence of the Beekmantown. Darton has however mapped it as extending some three or four miles farther to the northward. The writer has not been over the ground in that direction and does not know whether Darton's mapping there is based on actual outcrops or on inference. In either case we are here near the point of disappearance of the Beekmantown, beyond which the Trenton overlaps it on the pre-Cambrian.

There is an exceedingly interesting section at Diamond hill, demonstrating a local overlap of the Beekmantown there, which may be taken as illustrative of the whole process. As has already been stated, there is an exposure of the contact of the Beekmantown on the pre-Cambrian in the bank of Spruce creek at Diamond hill. Here the top of the pre-Cambrian is at an elevation of 1280 feet above sea level. But only a few rods to the northwest is a low knoll, all over which pre-Cambrian rocks are exposed, which reach an elevation of 1360 feet. Plainly we are here dealing with a low pre-Cambrian knob or hillock at least 80 feet in original hight, around which the Beekmantown was deposited before overtopping it. Sixty rods west of Spruce creek a little brook comes down which exposes a most interesting section of Beekmantown rocks some 25 feet in thickness. Then follows a gap of 25 yards in which are no exposures, after which are abundant outcrops of pre-Cambrian gneisses, the nearest to the Beekmantown rocks being at least 15 feet above them in elevation. That there is no

fault between the two is attested by the contact in Spruce creek, and by the study of the abundant outcrops on all sides. The Beekmantown rocks are quite sandy, and yet strongly calcareous (or rather dolomitic, effervescing only slightly with cold, but abundantly with hot acid). They contain numerous pebbles, not only of quartz but also of gneiss, identical with the white, quartzose Grenville gneiss of the hill. Moreover, these pebbles are considerably more numerous in the uppermost Beekmantown layers than in those below, for the evident reason that the exposed portions of the lower layers are at a greater distance from the pre-Cambrian rocks than is the case with the upper ones, that is, the pebbles increase in number with approach to the old shore line, as they would be expected to do. The accompanying section, drawn to scale, shows the actual conditions as observed, and also by dotted line the approximate position of the pre-Cambrian slope, the base on which the Beekmantown was deposited. The section seems to the writer to be decisive as to overlap.

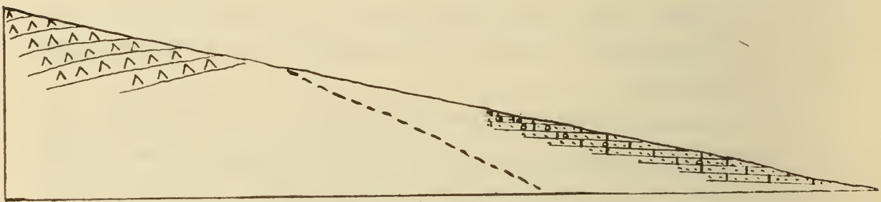


Fig. 12 Section near Diamond hill showing overlap of Beekmantown on pre-Cambrian. The Beekmantown strikes n. 45° w., dip 5 ° s. The pre-Cambrian rocks strike n. 80° w., with low northerly dip.

This overlap of the Beekmantown denotes a progressive sinking of the immediate district during Beekmantown time. Its successive layers from base to summit must rest in turn on the old rocks, after which the Trenton rests thereon. There is no known locality in northern New York where the Utica may be found resting undisturbed on the old surface, the reason being that erosion has everywhere cut below this horizon and removed every scrap of the Utica from such situation. But there seems no reason to doubt that the progressive subsidence continued intermittently during Lower Silurian time and for an unknown length of time thereafter.

Character and slope of the pre-Cambrian floor

The pre-Cambrian rock exposures of the Little Falls outlier extend for 2 miles in an east and west direction, with a general breadth of a half mile. While the contact with the overlying Beekmantown formation is actually shown in but two places, it is but scantily covered elsewhere, being within a few feet of showing continuously on both sides of the river. The surface on which the Beekmantown rests is surprisingly smooth and even. There are not even minor irregularities in it. For the first mile (between the two faults) it is nearly horizontal, though with slight westward inclination. Beyond the westerly fault it drops to the westward at the rate of 200 feet to the mile up to the point of disappearance beneath the river level. In this western portion the Beekmantown rocks slightly overlap on it, their fall to the west being slightly less rapid. The same may be true of the remainder though it is not certain.

The outlier at Middleville is not sufficiently extensive to afford much evidence in this connection. The creek has here cut down on the summit of a low fold. There is no evidence here of irregularity of original surface, but there is slight opportunity for such evidence.

The small outlier at the "Gulf", 2½ miles northeast of Little Falls, seems to represent the summit of a small knob of the old surface projecting up into the overlying Beekmantown. But it can not be much of a hill at best. The pre-Cambrian surface, at the fault line east of Little Falls, has an altitude of 700 feet; 4 miles to the northward, where it reappears from underneath the Beekmantown rocks to the west of the fault line, its altitude is 1000 feet; the little outlier is midway between the two and is at 860 feet elevation.

Along the main line of contact between the Beekmantown and pre-Cambrian the same evidence of comparative evenness of the rock surface on which Beekmantown deposition took place, is presented. Exposures are not all that could be asked, and at Diamond hill there is evidence of a low hill rising some 100 feet above the general level, that being the greatest irregularity of sur-

face indicated anywhere within the map limits. The surface seems to have been worn down to that of a gently sloping plain, above whose level, occasional low, rounded hills arose.

Though this evidence is meager in amount, and needs corroboration from adjoining districts, it seems specially important in view of the fact that Professors Kemp and Smyth, and the writer also, have found evidence to show that, in the St Lawrence and Champlain valleys and vicinity, the surface on which the Potsdam was deposited was considerably more uneven than this. In other words, the surface on the south was worn down to a nearer approach to base level than was the case farther north.[1] This may be accounted for in part by the fact that, since the Potsdam lies on the old surface there and the Beekmantown here, the surface here was a land area and undergoing wear during Potsdam time, or was a land area longer. The probable length of time involved would however seem insufficient to account for all of the observed difference.

A more probable explanation would seem to be that we are dealing here with a plain of marine erosion, and that its subsidence was slow, giving opportunity for the cutting of a considerable submarine terrace; whereas on the north the rather rapid subsidence during the Potsdam did not permit of the production of such a smooth and well defined bench, the district passing beneath the sea practically as subaerial erosion had left it, except for the removal of the weathered material.

Slope of the surface on which the Beekmantown was deposited. The Beekmantown rocks at Middleville are 200 feet in thickness. Seven miles to the northeast they have nearly or quite disappeared, and the Trenton rocks are overlapping on the pre-Cambrian. The pre-Cambrian surface has risen 800 feet in the interval, while the base of the Trenton has only risen 600 feet, the difference of 200 feet representing roughly the inclination of the surface on which

[1] Professor Kemp states in a letter that he has come to the same conclusions about the greater evenness in the south, away from the higher hills of the interior, from observations at the "Noses" and in the southern Hudson-Champlain valley.

deposition was taking place, indicating a slope of nearly 30 feet to the mile.

From Middleville to Ilion, in the opposite direction, the distance is 9 miles. The Beekmantown thickens 275 feet in the distance, from 200 to 475 feet, or again 30 feet to the mile.

From Little Falls northward to the spot of Beekmantown disappearance the distance is 15 miles. The Beekmantown rocks at Little Falls are 450 feet in thickness. This wholly disappears in the 15 miles, indicating again a slope of 30 feet to the mile.

The two latter measurements are both made in a nearly southerly direction and agree very closely. The first measurement is made in a southwesterly direction and falls somewhat short of the other two, which would indicate that the general slope of the surface was to the south. It is not meant to imply that this slope was maintained over any great distance, nor that it was uniform throughout, nor does it follow that the whole thickening to the south is due to overlap. But the figures do seem to demonstrate a southerly sloping sea floor, whose rate of slope was not over 30 feet to the mile, though it may have been somewhat less than that, and which is at least maintained throughout the area covered by the map.

As will be immediately shown there was some disturbance of the district during the early Trenton which must have affected this slope both in direction and in amount. Unfortunately also no quantitative data for determining the amount of this effect are at hand. But the effect could not have been great. If we assume that the effect was nil, and allow the Trenton rocks a thickness of 300 feet, which is close to their maximum hereabouts, then they would have only reached in 10 miles farther on the old surface than the Beekmantown rocks do, if the same rate of slope was maintained, beyond which the Utica would have overlapped on the surface. Nor would the Utica and Lorraine shales of the Hudson formation have extended in more than 30 miles farther over the region, even on the assumption that they were deposited to their full thickness, which is not likely. This line of evidence would therefore, so far as it may be worth anything, seem to indicate that

the southern Adirondack region could not have been completely submerged at the close of the Lower Silurian, much less so at the close of the Trenton. Here again the evidence is rather opposed to that on the north side of the region, as will be shortly shown.

Unconformity at the base of the Trenton

The great thickness of the Trenton formation at Trenton Falls, and its rapid diminution in thickness eastward across the area of the map have already been noted, together with the variation in thickness of the Lowville down to complete absence, the presence of the Black river limestone only here and there, and the fact that the passage beds between the Beekmantown and Lowville are not always present. Vanuxem, Darton and Prosser have all published valuable data along this same line, derived from the Mohawk valley to the eastward. The most significant section is that at Canajoharie, described by all three observers as showing a distinct, though slight, erosion unconformity between the Beekmantown and Trenton [*see* pl. 10, and compare with pl. 5]. Prosser measured but 17 feet of Trenton here, and this seems to represent only the upper beds of the formation, while both the Lowville and Black river are wholly wanting. At Sprakers, 3 miles farther east, Prosser's section shows again but 17 feet of Trenton, with no sign of the Lowville and Black river. Nothing is said about an unconformity at this point and apparently the actual contact is not exposed.

Eastward from Sprakers the Trenton slowly thickens, and the Lowville and Black river limestones reappear. Prosser's numerous and accurately measured sections, published in the 15th Annual Report of the State Geologist, show that all three are usually present, though occasionally either the Lowville or the Black river is lacking, and the combined formation does not regain any special thickness, being always under 50 feet.

From these facts it is evident that the rather steady, progressive subsiding movement which characterized the region during Beekmantown deposition, and which resulted in the rather constant thickness of that formation of from 450 to 550 feet throughout the Mohawk valley (except where thinned by overlap), was

N. H. Darton, photo.

North bank of creek south of Canajoharie N. Y. exhibiting the relations of the Trenton limestone, horizontal Trenton resting unconformably on slightly folded Beekmantown; the Lowville, Black River and lower Trenton being absent

interrupted at the close of the Beekmantown conditions. There is little evidence that the subsiding movement was changed to one of elevation, except locally about Canajoharie, where it would seem that a slight arching of the surface occurred, accompanied by some slight erosion, before the downward movement was resumed late in the Trenton. Otherwise conditions seem best accounted for on the assumption of a check to the downward movement, which was thence forward in very slight amount for a time, with many small local variations. With cessation of subsidence deposition must soon cease and the evidence of local variations is convincing. The field evidence led the writer to the belief in an unconformity at this horizon, before the search through the literature made him aware that others had brought out evidence along the same line.

Absence of the Chazy formation in the Mohawk valley

One effect of this pause in subsidence (with perhaps slight accompanying uplift) was to effect an entire separation between the basin of Mohawk valley deposition and that of the Champlain valley, for the time being. In the latter we have a great formation, the Chazy limestone, with a maximum thickness of 800 feet in Clinton county, interposed between the Beekmantown and the Trenton. This formation rapidly diminishes in thickness when followed to the southward in the Champlain valley and wholly disappears before the Mohawk is reached. Its thinning and disappearance seem to be due to a progressively diminishing rate of subsidence toward the south, rather than to overlap. This point will be again reverted to; and, if well taken, it follows that, while a considerable downward movement, progressively greater toward the north, was taking place in the northern district, little or no subsidence, and hence an almost complete interruption of deposition, characterized the southern region during the time interval represented by Chazy deposition.

Sudden thickening of the Trenton westward

At Trenton Falls the Trenton limestone has a measured thickness of 270 feet, which must be increased by an unknown but small amount, since neither the base nor the summit shows in the sec-

tion there. At Middleville, 13 miles to the southeast from Trenton Falls, the Trenton is only about 100 feet thick, excluding the passage beds but including the Lowville. From Middleville on to Ingham Mills and thence to Canajoharie, the thinning goes on, but much less rapidly. Now unquestionably a portion of this diminution is due to the interruption of subsidence, this interruption being most pronounced at Canajoharie, thence diminishing both eastward and westward, apparently much more rapidly westward. But the writer is strongly impressed with the possibility, nay probability, that it is in part due to a change in the character of the sedimentation going eastward; in other words that the upper portion of the Trenton of the Trenton Falls section passes laterally, by increase in amount of shale and by disappearance of the few heavy limestone layers, into what are here mapped as passage beds. A large part of the upper half of the Trenton at Trenton Falls, judging from the descriptions of Prosser and White, consists of alternating layers of thin limestone and shale containing few fossils, the whole being capped by the heavy, gray, crystalline limestone at Prospect. With a thinning out and disappearance of this upper heavy layer, very slight change in what lies beneath would give it typical passage zone character, and the gradual downward encroachment of this zone might be very effective in thinning the typical Trenton beneath.

Comparison with the northern Adirondacks

In the lower Champlain valley, on the New York side, the Paleozoic section comprises the

	Feet
Potsdam formation, maximum thickness unknown but more than	800
Beekmantown formation, maximum thickness	1800
Chazy formation, maximum thickness	800
Trenton (including Black river), thickness unknown, at least	250
Utica shale, thickness unknown but great	

This section is at least 3000 feet thicker than that of the Mohawk valley, and likely considerably more, the main part of

the excess being in the lower portion of the section. Data as to the slope of the floor on which these rocks were laid down are lacking, though the evidence is clear that it was by no means so even as it is about Little Falls. On the other hand, the surface was by no means so rugged as much of the present Adirondack surface. Yet, with the surface as at present, the thickness of Paleozoic rocks laid down on the north would suffice to blanket the whole region with them, if extended to the south over it. Because of this, the writer has argued in a previous publication that the entire Adirondack region was likely submerged at the close of Utica deposition. Following an entirely different line of argument, Ruedemann has contended for nearly complete submergence *during* the Utica.[1] The evidence on the south seems however somewhat opposed to these conclusions, and at least warrants the statement that any portion of the region which may have remained unsubmerged during or at the close of Utica deposition, was in the southern Adirondacks.

The fact that the deposits of the early Paleozoic are thickest on the northeast, diminishing thence west and south, implies more rapid and more steady subsidence in that part of the region. And the vastly greater quantity of land wash carried into the northern sea indicates that the prevailing drainage of the present Adirondack area was to the north. Along this line may come a propable explanation of the apparently conflicting evidence from the north and the south in regard to the submergence of the district at the close of the Utica.

It seems to argue that the summit of the Adirondack island was toward the southern part of the present region, and if it was not distant more than 30 or 40 miles from the present border it would have become submerged by the close of the Trenton at the estimated rate of overlap.

TOPOGRAPHY

The present topography of the Little Falls district is the result of, and expression of, its long and complicated geologic history. The pre-Cambrian submergence with its deposits, the pre-Cam-

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[1]Ruedemann, R. Am. Geol. June 1897 and Feb. 1898. p.75.

brian elevation into a land area with its long protracted erosion and its igneous action, the Paleozoic submergence and deposition, and the ensuing and still continuing elevation above sea level, with its erosion, its oscillations of level and its disturbance by faulting, all have their share in the present topography; and, lastly, the recent Glacial period with its advancing and eroding, and its retreating and depositing ice sheets, is entitled to a very large share of responsibility for present conditions.

Pre-Cambrian surface

Evidence as to the character of the pre-Cambrian surface at the close of the long period of pre-Cambrian erosion, has already been presented, and it has also been shown that it is here more nearly a plane surface than is usual in the Adirondack region. The writer is disposed to regard the more even surface here as representing a plain of marine erosion, more even than on the north, because subsidence was less rapid and of a more intermittent character here, so that the action of the waves was longer continued at a given level.

As the district emerged from the sea after the deposition of the Paleozoic rocks, it appeared in all probability as a coastal plain, with gently sloping, quite even surface. The present pre-Cambrian surface exposures are such because the Paleozoic cover has been removed by later erosion. Along the contact line of today we see the pre-Cambrian surface as it was when originally covered by the later rocks. As we recede from that line, the pre-Cambrian rocks have been exposed to progressively longer wear, during which the less durable rocks have lost more than those of greater durability, and more material has been removed from along the stream courses than from the interstream areas; hence the surface is now one of hill and valley. In regard to this present surface two things seem quite clear, first, that the hilltops rise to quite concordant altitudes, with a general increase in elevation to the northward, and second, that the comparatively plane surface which would be produced by filling up the valleys to the level of the hilltops, does not correspond in inclination with

the yet more even surface on which the Paleozoic rocks were laid down. The evidence is in brief as follows:

Examination of the Little Falls topographic sheet shows a progressive rise of the pre-Cambrian hilltops going northward, the highest elevations reached being somewhat over 2000 feet. On the Wilmurt sheet (lying directly north of the Little Falls sheet) the same fairly concordant altitudes are to be noted, and the same slow increase northward, the higher summits in the northern part of that sheet showing elevations slightly over 2500 feet. This is an increase of about 500 feet in 18 miles, or between 25 and 30 feet to the mile. Northward along the western edge of the same sheet the rise is somewhat more rapid, about 50 feet to the mile.

Some idea of the general slope of the pre-Cambrian surface underneath the Paleozoic rocks may be obtained by comparing the altitudes of this surface at Little Falls and at Diamond hill for one line, and from Ilion through Middleville and thence northward for another line.

Diamond hill is 8 miles north of Little Falls. The Spruce creek contact there is at 1200 feet altitude. The pre-Cambrian in the river above Little Falls, taken at that point in order to avoid the lifting effect of the fault as much as possible, is at 400 feet. Thus there is a rise of the pre-Cambrian surface of 800 feet in the 8 miles, or 100 feet to the mile. Since Diamond hill is farther away from the upthrow influence of the fault, this amount is probably a little too small.

In the well at Ilion the pre-Cambrian was reached at 1105 feet, or 700 feet below sea level. At Middleville it is 500 feet above tide, a rise of 1200 feet in between 9 and 10 miles, or about 130 feet to the mile. Ten miles north of Middleville the pre-Cambrian appears from under the Trenton at 1300 feet altitude, a rise of 80 feet to the mile.

While these results are not particularly concordant, and while more data are much to be desired, they do seem to indicate that the one surface falls to the south more rapidly than the other, say from two to three times as rapidly. Both surfaces fall also

to the west, but the north-south direction was chosen in order to avoid the tipping produced by faulting, so far as possible.

Since the erosion level whose presence is indicated by the concordant hilltop altitudes does not correspond with the older erosion plane on which the Paleozoic rocks rest, but makes an angle with it, it follows that it must have been developed during a later erosion period. It follows further that the more we recede from the present Paleozoic contact line, the more deeply erosion has cut away the pre-Cambrian rocks.

The area under discussion is so small, and the writer has so little familiarity with the surrounding district, that it would be folly to attempt to trace the erosion level beyond the district, either north or south. That it represents an old level is quite clear, and that it should also be traceable south of the Mohawk is equally clear. The larger portion of the area of the Little Falls sheet has been cut down by later erosion to a lower level. It should be pointed out, however, that the concordant hilltop altitudes, as found here, are also found in the northwestern Adirondacks, but are not to be found on the east and northeast, because of which the writer has argued for recent movements along the fault planes in the latter district as a probable reason for their absence; that is, that the erosion surface was produced there as on the west and south, but that its continuity has been broken by recent differential movements along the old fault planes.

Present surface of the Paleozoic rocks

As the Little Falls district emerged from the sea after the deposition of the Paleozoic rocks, it presented a low and quite smooth surface, with a gentle inclination to the south or southwest. Since at present the rocks are but slightly tilted from their original nearly horizontal attitude, the original uplift, as well as all others since, has affected their inclination but little. The diagram, figure 13, represents a rude attempt to illustrate the structure of the region on emergence, on the assumption that this took place at the close of deposition of the Medina sandstone of the Upper Silurian. This is in all probability not the case, but

the rocks included are all that are now represented in the immediate district, and the diagram is just as suitable for illustrative purposes as if the higher rocks were added. As the district became a land area, streams would extend themselves across it and commence to wear out valleys, tributaries would develop to these main streams, the topography would become more irregular because of this wear, and the precise sort of irregularity developed depended on certain special characteristics of the district. These were the original south slope of the surface, the gentle inclination of the rocks, the variation in resistance of the different formations, and the fact that the Paleozoic cover was thinner at the north than

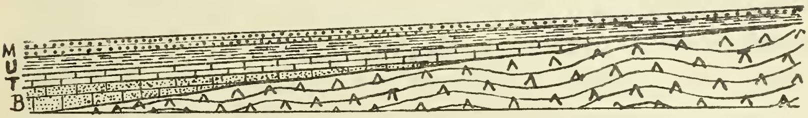


Fig. 13 Diagram to illustrate the condition of the region after deposition of the Paleozoic rocks and emergence above sea level, with smooth, southerly sloping surface B=Beekmantown, T=Trenton, U=Utica and Hudson shales and M=the Oswego and Medina sandstone formations of the Upper Silurian.

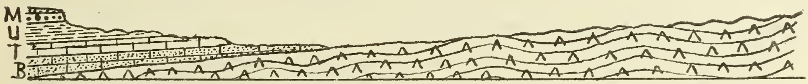


Fig. 14 Diagram to illustrate the topography produced as a result of prolonged erosion on the district shown in figure 13. The erosion stage represented is that of greatest possible relief.

at the south. In figure 14 an attempt is made to indicate the character of the surface produced at a certain stage of the erosive process. The Medina is the most resistant of the Paleozoic rocks included, followed in order by the Beekmantown, Trenton and Utica. The Medina would be first cut through by the streams at the north because of its higher altitude there. Once the softer rocks beneath were exposed, erosion would proceed more rapidly. The pre-Cambrian rocks would be first uncovered on the north, both because of higher altitude and because the Paleozoic cover was thinnest there. This slow removal of the Paleozoic cover would then advance southward. The successive Paleozoic formations would then be found infacing toward the old surface on which they were originally deposited. The harder and more resistent layers would inface as lines of cliff, or escarpment, running

roughly parallel to the old shore line. Such an escarpment would be specially prominent when the underlying rock was very weak. The resistant Medina sandstone, overlying the weak Hudson shales, forms just such a combination, and the Medina escarpment is a prominent feature of the district south of the Mohawk, though lying beyond the limits of the map.

Since the Beekmantown is more resistant than the Trenton, and that more so than the Utica, erosion tends to strip the Trenton from off the Beekmantown more rapidly than the latter can itself be worn back, and thus to leave a bared strip, or terrace formed on the upper surface of the Beekmantown. For a like reason, a terrace tends also to develop on the upper surface of the Trenton as the Utica is worn away, the level of the Trenton terrace dropping rather abruptly to that of the Beekmantown over the low escarpment formed by the edges of the retreating Trenton layers. Likewise a terrace tends to form on the even pre-Cambrian surface bared by the removal of the Beekmantown, since the former rocks are vastly more resistant.

With the district at a given elevation, wear can be carried on only down to a certain level, determined by the slope necessary to permit the streams to carry away their load of rock waste. The soft rocks will be worn down to this level long before the hard rocks reach it. But then wear ceases on the soft rocks while still continuing on the hard. Therefore features of relief produced by varying rate of wear can reach only a certain degree of accentuation, after which the effect of erosion is to diminish their strength, and, if the region persist sufficiently long at the given level, all rocks, hard as well as soft, will be worn down nearly or quite to the level of the stream bottoms. Renewed uplift will however cause the streams to renew down cutting, again the soft rocks will go down first and the hard again come to stand above their level, resulting in a reproduction of the previous features, the only difference being that they will be shifted to the southward of their position in the previous erosion cycle. The amount of relief obtainable in each cycle will also depend on the amount of uplift.

Now this region has been continuously above sea level for a long time, long enough for erosion to have pared away all rocks, hard as well as soft, down close to base level, and this not only once but more likely several times. That the district is not in this leveled condition but has, well developed, the topographic features outlined above, hard rock escarpments, soft rock valleys and terraces, is in itself indicative of renewed uplift, and that of no very remote date.

There appears also to be evidence that, prior to this uplift, the region had persisted sufficiently long at the previous elevation to have become pretty thoroughly worn down. Such evidence of this as exists in the immediate neighborhood is found in the concordant altitudes of the Adirondack hilltops to the north, and the hard rock plateau summits to the south of the Little Falls sheet. But the district in question is not sufficiently covered by the new maps, nor is the writer's personal acquaintance with it sufficiently extensive to warrant more than the simple statement of his belief that the Cretaceous peneplain, recognized as of wide extent over much of the eastern United States, is recognizable in the southwestern Adirondack region.

Influence of the faults on the topography

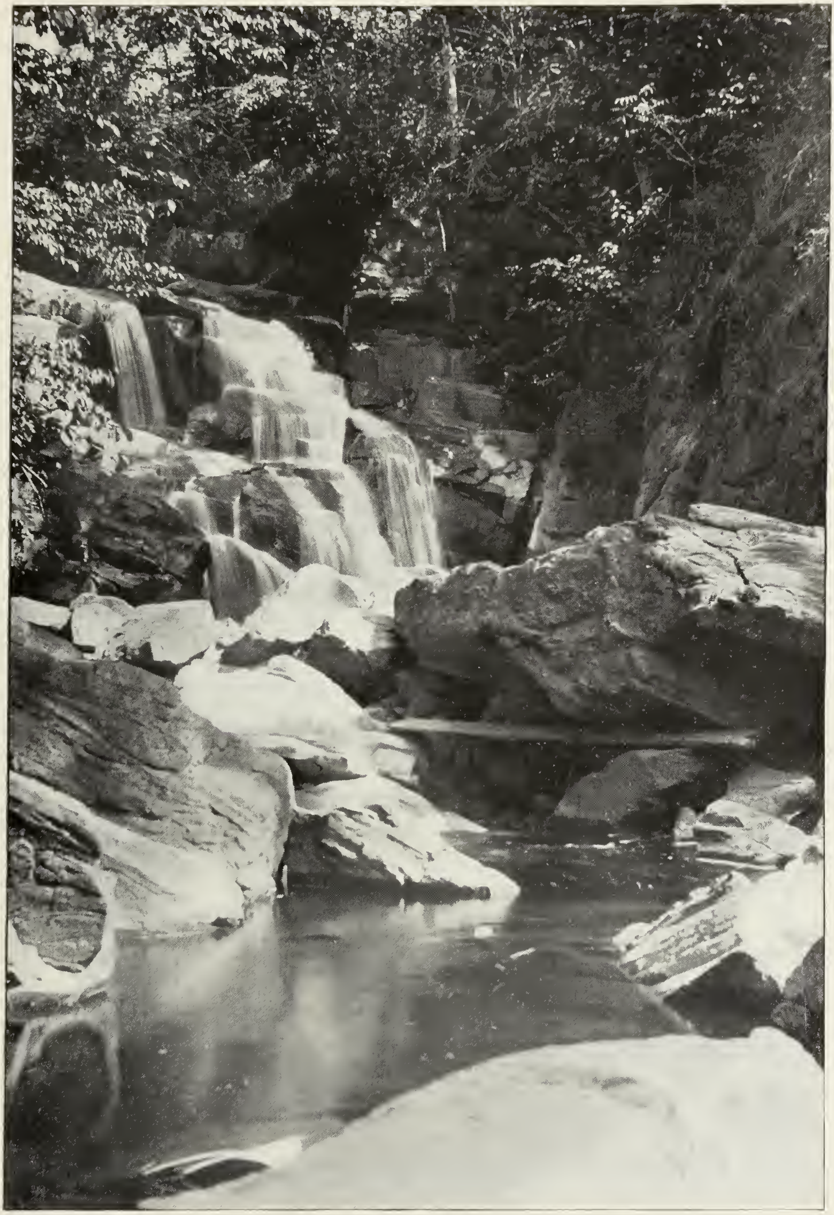
As newly formed, faults like that at Little Falls produce lines of cliff known as fault scarps along the edge of the upthrown block. Though faulting is a slow process, and though the rising upthrow side is subject to more rapid erosion than the other side because of its greater elevation, so that in all likelihood no fault scarp has ever had a hight equal to the amount of the fault's throw, yet newly formed faults should present scarps whose hight should represent a very respectable percentage of the amount of throw at least.

As time passes, the greater wear on the upthrow side will cut it down to the level of the other and the scarp will cease to exist. It may be made to reappear in one of two ways: first, by renewed faulting taking place along the same line; second, by renewed uplift of the region without faulting. In the latter case the rock

on one side at the surface is likely to be more resistant than that on the other, and the more rapid wear in the softer rock will again bring the fault into some prominence as a topographic feature, the amount depending on the difference in resistance of the two rocks concerned, and on the amount of uplift.

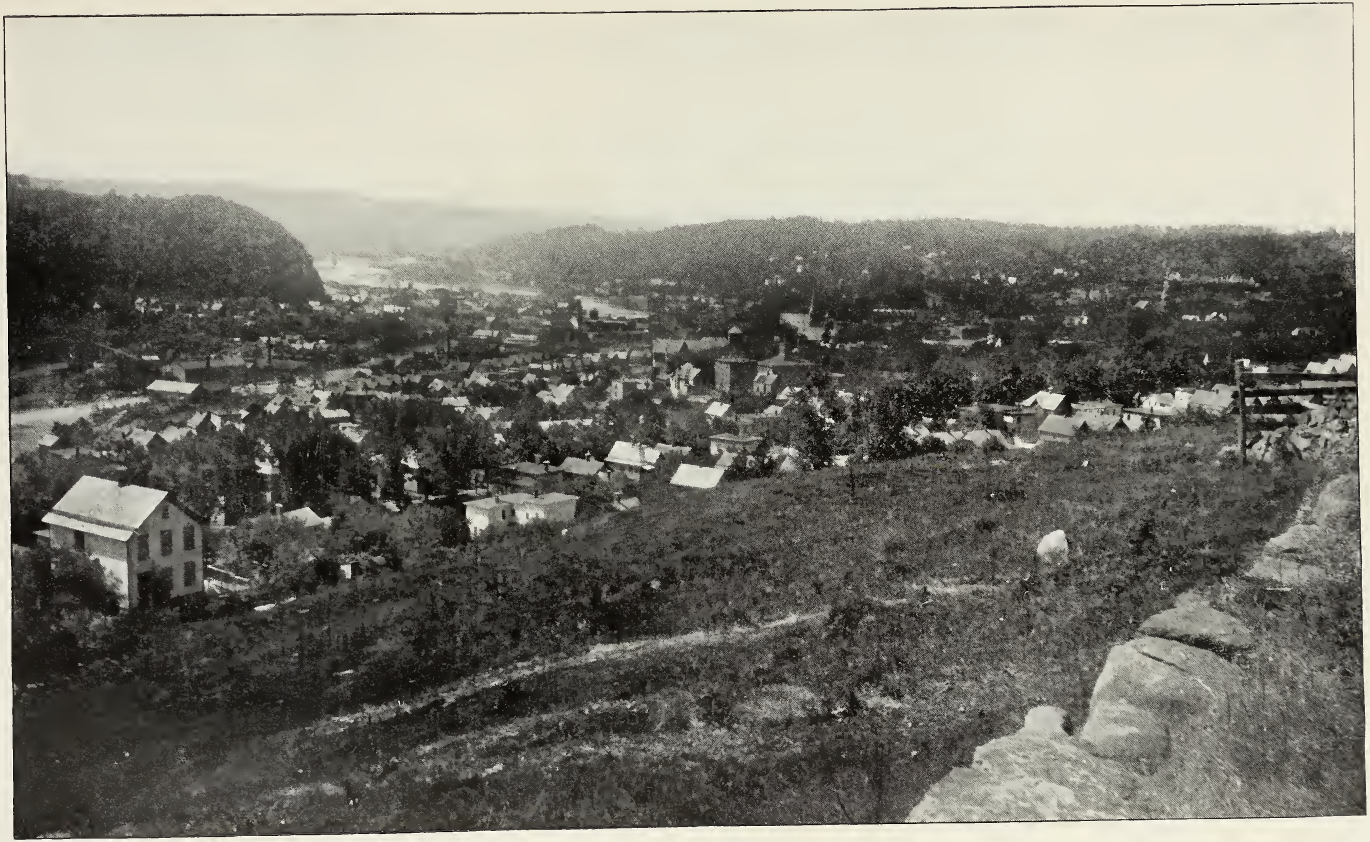
When the faults of the district are examined with these principles in mind, it is at once seen that they are at least sufficiently old, so that the original scarps have been utterly obliterated as topographic features; that no recent slipping has taken place along them; and that such small show as they make in the present topography is due to the rather recent uplift of the region as a whole. The Little Falls fault makes no considerable show in the topography except along the immediate channels of the streams which cross it, all of which show falls or rapids, and gorges below, in the harder rocks of the upthrow side, with sudden change in the character of the valley as the fault line is crossed [*see* pl. 11]. This is most impressively shown along the Mohawk, the broad, mature looking valley developed in the weak Utica shales east of the fault contrasting sharply with the narrow gorge in the resistant rocks west of it, and the fault scarp being a prominent feature when looking up the valley [*see* pl. 12, 13]. Away from the streams, where the fault affects the topography at all, it appears as a low escarpment, with gently sloping instead of steep front, the slope being down the dip of the updragged Utica beds on the downthrow side. Where the very resistant pre-Cambrian rocks are on one side with the Utica shale on the other, the fault is fairly prominent and would be more so were it not for deep drift deposits on the lower side.

The larger faults do, however, have an important indirect effect on the topography. Since they run north-south, and since the uplifting of the west side has given the rocks there a tilt to the westward, in addition to the usual south dip, giving them a local north-south strike, erosion has developed the Beekmantown and Trenton escarpments and terraces there with a north-south trend, at right angles to their usual direction [*see* pl. 14]. The pre-Cambrian terrance is also well developed on the west side of the



H. P. Cushing, photo.

Fall in creek over the pre-Cambrian at the Little Falls fault line 2 miles west of Dolgeville. The creek is in a postglacial valley, and has only cut back its fall 100 yards from the fault plane, the volume being slight and the rocks very resistant. The perpendicular walls of the gorge below are due to the joint planes, and the large loose blocks are dislodged mainly by frost.



N. H. Darton, photo.

Looking up the Mohawk river from the eastern part of Little Falls. Crystalline rocks in bottom of gorge; cliffs of Beekmantown dolomite in foreground; hills of Utica slate in background

H. P. Cushing, photo.

Looking down the Mohawk from the brink of the Little Falls fault scarp, showing the broadly open character of the valley, as contrasted with its narrow character above shown in plate 12. The fault scarp here is prominent and about 200 feet high, but this prominence is only local and due to the nonresistant character of the rock below the fault line, as compared with that above; so that the river has excavated a broad valley in the former while still working at its gorge in the latter.

H. P. Cushing, photo.

Looking down on the Trenton terrace from the Utica shale slope to the west. Taken from a point 4 miles west of Dolgeville, and looking east

Little Falls fault, in the northern part of the sheet. From this standpoint therefore the large faults do yet exert a large influence on the topography in their vicinity.

PLEISTOCENE (GLACIAL) DEPOSITS

The Pleistocene deposits of the district, and the history which they record, can receive adequate consideration only after a thorough study of a wide area. Brigham has recently published an excellent paper on the "Topography and Glacial Deposits of the Mohawk Valley," containing numerous references to the literature of the subject.[1] The writer has been over such a scant amount of the area that he can add little save some local details to the general discussion.

The amount of glacial erosion in the district does not seem to have been great. The soil and weathered rock were removed and the underlying rock surfaces scoured and polished, but the general topography seems to have been but scantily affected.

Professor Chamberlin has discussed the general ice movement in the Mohawk valley, holding that there was an easterly moving ice tongue in the western portion of the valley, and a westerly moving one in the eastern portion, the two meeting near Little Falls.[2] His final statement sums up as follows:

> I hesitate, at this stage of the inquiry, to encourage any confident opinion in regard to the exact history of glacial movements in the Mohawk valley, further than the general presumption that massive ice currents . . . swept around the Adirondacks and entered the Mohawk valley at either extremity, while a feebler current, at the hight of glaciation, probably passed over the Adirondacks and gave to the whole a southerly trend.

The readings of glacial striae which he reports are quite in accord with this view; and with it the writer's similar observations also agree.

Away from the valley the writer has only two observations on striae, not a sufficient number on which to base any deductions. One mile north of Salisbury Centre striae bearing s. 30° e. were

[1] Geol. Soc. Am. Bul. 9:183-210.

[2] Chamberlin, T. C. United States Geol. Sur. 3d An. Rep't. p.361-65.

observed near the summit of a knoll of pre-Cambrian rock. It is not certain whether the movement was to s. 30° e. or to n. 30° w. though in all probability the former.

Near White creek, $2\frac{1}{2}$ miles north of Middleville, one of the tributary creeks just uncovers, in its bed, the summit of a hill capped by Trenton limestone, on which are plentiful striae bearing n. 80°e. Since this is a hill summit, no rock showing in the banks, and none in the bed either above or below, it should give the general ice direction, and accords well with the records nearer the Mohawk.

The only possible criticism to be made on Professor Chamberlin's quoted statement is that it might lead the reader to hold the view that general glaciation in the Adirondacks was not severe and long continued, and such view is certainly erroneous.

In general, the glacial deposits are not exceedingly bulky over the limits of the sheet, and over much of it they are very thin, the underlying rocks not only outcropping along the streams but repeatedly in the interstream areas. The drift is heaviest in the northwestern part of the district, where the rocks are effectively concealed over many square miles. There is also heavy drift north of Dolgeville.

Till. The till varies much in character, the variation being mostly in the rock ingredients, which are mainly of quite local origin, as is usual. In and near the pre-Cambrian area it is rather light colored and excessively sandy, and this is its character throughout the Adirondack region. Elsewhere it is nearly black and much less stony, which is due to its large content of soft, black Utica shale. It seems to acquire large depth only where filling preglacial valleys. The black till is magnificently exposed in the banks of West Canada creek and many of its tributary creeks from the east, often forming perpendicular cliffs up to 100 feet and more in hight. There are also high till banks in Spruce creek north of Dolgeville, and in the creek tributary to East Canada at Ingham Mills. In these the till is overlain by heavy sand deposits, at the base of which large springs issue.

Moraines. The heaviest development of morainic accumulation within the map limits is along a line running southeast from the northwest corner to Barto hill and thence eastward through Salisbury Centre to the easterly limits. The moraine is broad on the east and west but narrows in the center. On the east it is associated with a considerable development of kame hills and great overwash sand and gravel terraces. On the west these features are lacking. There is a line of kames to the north of Salisbury Centre, culminating in the "Pinnacle", and to the south of this line a great development of low sand hills and terraces. On the west the kames and sands are lacking, the moraine is associated with heavy till, and, though broad, has no great depth over the till. This moraine would seem the eastward prolongation of the one mentioned by Brigham as blocking the valley at Holland Patent, and the topographic maps seem to indicate that much of its course between is marked by heavy kame sands, as is the case here.[1] West of West Canada creek a heavy moraine appears which would seem to serve as a possible connection between the one above described, and the one described by Chamberlin as coming up to Ilion from the southwest.

Sands and laminated clays. Northward and northwestward from Dolgeville is an area of deep sands. Much of it is built into kame hills in association with the moraine. Much however forms flat topped benches with steep sloping fronts. Boulders occur here and there on the surface, though always sparsely. Some gravel is often associated. They lie at all sorts of levels from 800 up to 1500 feet. Their form is often that of delta deposits, but, if such, they represent merely very local and rather rapidly shifting water levels. If the moraine was formed by the shrinking Mohawk glacial lobe, persisting after all ice had disappeared from the foothills to the north, there would be opportunity for the formation of small local lakes along the ice edge, while retreating back from this position, in which the discharging waters of both East Canada and Spruce creeks would build successive

[1] *Op. cit.* p.191.

deltas as the water level fell. It will be an interesting matter to determine if any correlation be possible between these levels and corresponding ones formed by West Canada creek.

South of Dolgeville, and east of the creek, is a sand terrace with summit level of 800 feet, and a line of morainic hills to the east which culminates in the knob just opposite Dolgeville. The sand overlies till, has a depth of from 20 to 40 feet, and seems to be a delta deposit, of East Canada creek in all probability.

The sand and gravel shoulder about Herkimer, with summit at about 600 feet, has been correlated by Brigham with similar deposits farther up the Mohawk valley at the same approximate level, all of which he regards as having been formed in a small lake with water at the 600 foot level, held up partly by ice at Little Falls and partly by the rock barrier there, since trenched by the river.

Below Little Falls is a prominent sand and gravel terrace, with much coarse gravel on the north side of the river, whose summit is between 460 and 480 feet. It is found on both sides of the river, though most extensively and least interrupted on the north. Though slightly higher, these levels are quite concordant with those of the similar deposits described by Brigham as extending from East Creek (just beyond the map limits on the east) down to Amsterdam, at about the 440 foot level, and regarded by him as indicating static water at that level, held up by some as yet unknown barrier at or below Amsterdam.

At several localities finely laminated, plainly water-laid clays, nearly or quite destitute of pebbles, were noted. They seem of necessity to mark static water conditions, yet are at such varying altitudes, and run up to such high levels, that they can be attributed only to a series of wholly independent and very local water bodies.

Just west of Dolgeville is a flat topped, steep fronted sand and gravel terrace with a summit elevation of 840 feet. One and one half miles north of Dolgeville, on the divide between Spruce and Cold creeks, are finely laminated clays at 900 feet. The lamination is so fine and even that the material was mistaken for

weathered Utica shale before it was closely examined. To the north, and overlying this, is a sloping sand terrace at from 1000 to 1040 feet, followed to the north by the heavy sand hills of the kame moraine. The whole combination seems to indicate a local obstruction of the drainage coming down from the north by the ice lobe, as it was retreating south from the position of the moraine, forming a small lake in which the clay was laid down, on top of which the streams thrust out a delta. Further retreat permitted the formation of the lower delta near Dolgeville.

Still farther north, the "Pinnacle" kame sands are seen to lie on a similar laminated clay, which there is at 1200 feet. In the single exposure seen the dip is at first nearly flat and then rapidly changes to one of 45° to n. 50° w., suggesting a possible disturbance by the ice, in which case the clay would antedate the last ice advance.

In the tributary to Crum creek at Manheim Center, at an elevation of 520 feet, is a laminated, fine clay with occasional minute pebbles. It lies too high for association with the 440 foot water level, and seemingly too far east to have any relationship with the 600 foot level west of Little Falls. It shows no associated sands, and appears to be overlain by morainic accumulations, in which case it also must have been laid down prior to the last advance of the ice.

But whether these different clays are older or younger than the time of last ice advance, their great variation in altitude affords a difficult matter for explanation, and seems to the writer to indicate small water bodies produced by extremely local conditions.

Drainage. Brigham has sketched an outline of the drainage development of the district in preglacial times, with which the writer is in full accord and to which he can add nothing. To this, those interested are referred.[1]

Just before the onset of the ice, the drainage of the district consisted of the main, east-west trunk valley, worn out along the belt of weak rocks under the Medina, into which came tributary streams from the north and south, the whole constituting a well developed drainage network which had carved prominent valleys.

[1] *Op. cit.* p.184-92.

The main valley was only partially filled by glacial deposits, and was reoccupied as the main drainage channel on the retreat of the ice. The main change effected was the shifting of the position of the divide between the easterly flowing stream in one, and the westerly moving drainage in the other end of the valley. The present divide is at Rome, is of the most trivial description and is composed of glacial deposits which manifestly could not have formed a preglacial divide. The preglacial col was in all probability at Little Falls, as urged by both Chamberlin and Brigham. Here the valley is narrowest, here is the most resistant rock mass anywhere in the valley, brought up on the west side of the fault, and here the drainage adjustment of the long, preceding time of wear would inevitably locate the divide.

After the ice had disappeared from the Mohawk valley but was still blocking that of the St Lawrence, the waters of the Great lakes went to the sea by the Mohawk valley route, and this great rush of water must have been very efficient in cutting away the rock obstruction at Little Falls. On the other hand, it is obvious that at this time the divide could by no means have had the hight of the present valley walls, nor even that of the pre-Cambrian surface at the fault line (600 feet), the latter being more than 100 feet above the present divide at Rome. Chamberlin has suggested that the outer and wider gorge at Little Falls was cut during interglacial times, and this is very probable; at all events, it is certain that the inner gorge represents the total amount of cutting since the ice retreat. This interglacial erosion of the col, together with the heavy drift deposition about Rome, shifted the divide to that point, so that between the two points there is now easterly, where formerly was westerly, flowing drainage.

Brigham has argued that the preglacial course of West Canada creek was by way of Holland Patent, where now is a broad, open valley occupied by a small stream. Certain it is that from Prospect to its mouth the stream is not in its old channel, and that from Prospect to below Trenton Falls it is not in an old channel of any sort.

From Middleville to Herkimer the course of a small preglacial stream is apparently followed, whose source was at Middleville,

D. McBride, photo.

View on East Canada creek ½ mile above Dolgeville, where its course is through a drift-filled valley. Compare with plates 6-9.

where there was in all likelihood a minor divide, located by the more resistant rocks domed up there. This col must also have been cut down in glacial times and quite probably by glacial erosion at a time when the full current of ice swept over the Adirondacks. Though constricted, the valley is not a gorge at Middleville, is U-shaped, there is neither fall nor rapid in the stream, and the knobs of pre-Cambrian rock near the creek level show unmistakable evidence of glacial wear. Just above Middleville, too, the valley is heavily clogged with drift to below the creek level, and even immediately below the town, where the valley is narrowest, till descends in places to the stream level.

East Canada creek also, so far as it lies within the map limits, is not in its old valley, though where that was can only be conjectured. From Dolgeville to the fault line it is in a wholly postglacial valley, with rapids, and a high fall with a gorge below. Below the fault the stream enters the east side of a preglacial valley, which lies to the west of its present course, and out of which it turns into the modern gorge above Ingham Mills. For a mile below Ingham it apparently crosses another preglacial valley, nothing but drift showing in the banks and bed, and begins to disclose rock again in the bed just before leaving the sheet, beyond which it has cut another rock gorge.

North of Dolgeville the stream is in a preglacial valley, out of which it turns at the big bend to the east [*see* pl. 15, and compare with pl. 6, 7, 8, 9]. To the northward along this line there is heavy drift, with no rock showing, for some miles; and on the prolongation of the same line to the south no rock exposures occur over a belt at least a mile in width, all the way to the Mohawk. The course of a preglacial valley, rather closely following the Little Falls fault line and lying between that and the present valley of East Canada creek, is thus rendered probable, and such a valley would also seem likely on structural grounds, adjusted to the belt of weak Utica shales between the Little Falls and Dolgeville faults.

The smaller tributary creeks all show the same general features; here they develop rapids, falls and gorges; above and below they show nothing but heavy drift in banks and bed. Their present

courses were determined by the contours of the deposits left by the retreating ice sheet, and do not correspond with the old valleys in position but cross them at varying angles. The present rock-bound portions of their courses are due to the uncovering of hill-tops and divide summits of the preglacial topography, which lay buried beneath their modern courses when they first assumed them. When they occupy, or cross, old valleys, they have not yet been able to cut down to their rock bottoms and have only partially removed the drift filling. The modern valleys are not as large, as deep, nor as mature, and the surface relief is not as great as before the appearance of the ice.

Spruce creek presents some interesting features. All the upper part of its course closely follows the pre-Cambrian edge. This contact forms a natural drainage line because of the southwesterly slope of the resistant pre-Cambrian surface uncovered by the retreat of the Beekmantown inface, and there must certainly have been a preglacial stream here. Brigham has noted the corresponding position of Black river, which follows this contact for miles.[1] The present divide between Spruce creek and Black creek (an affluent of West Canada creek which flows to the northwest along the contact line) is a moraine ridge near the north limit of the sheet. Both these streams are in their old valleys, though where the preglacial divide was is uncertain, the writer however suspecting that it was at or near Diamond hill, and that the present upper part of Spruce creek is in the old Black creek valley, the drainage now being reversed. However that may be, the gorge at Diamond hill is modern, either because of the cutting down of a col, or because the stream is there turned aside out of its old valley. Just below, the valley is blocked by a moraine, and to the eastward of the gorge no rock shows at the surface for a mile, so that we are not limited to the supposition of a col at this point to explain the present course of the stream. From Diamond hill to the fault line the stream is occasionally out of the old valley, specially at Salisbury Center, thence its course to its mouth is

[1] *Op. cit.* p.186.

through the drift of the old, deeply filled valley east of the fault line. There is no wide outlet valley into this through which the preglacial Spruce creek could have come, and there must have been once a col at the fault line, but this would have been cut back, and the narrowness of the old valley would seem due simply to the great hardness of the pre-Cambrian rocks in which it was cut.

The heavy drift filling for several miles east of the fault line, as contrasted with the abundant rock outcrops on the west side, shows that in preglacial times the fault was a more conspicuous topographic feature than is the case now, and this by an amount measured by the unknown thickness of the drift over the rock on the east side.

These old, buried valleys introduce an element of uncertainty into the areal mapping of the rocks. For the most part they must be ignored, since their location is unknown; and, where they have been located, the depth of drift is unknown, so that the precise rock horizon beneath can not be told. Whenever they exist, the areal map is likely to be somewhat in error in regard to the surface rock.

ECONOMIC GEOLOGY

Building stone. The Lowville limestone has been the main quarry rock of the district, and has had a considerable local use. It is in general quite massive, not excessively jointed, of pleasing color and quite durable. It has been more largely quarried at Ingham Mills than at any other locality, though several other quarries have been opened, the location of the principal ones being shown on the areal map. The big Dolge mills at Dolgeville are constructed of it, the locks of the Erie canal also and many other smaller structures. It makes a most excellent building stone, admirably fitted to supply all local necessities of the sort. It has also been somewhat burned for lime and would seem the most suitable of the local rocks for the purpose.

The Beekmantown rocks have been somewhat quarried at Little Falls, the lower layers being used, and slight openings have been made elsewhere. While not as good as stone as the Lowville, this

rock has had considerable use at Little Falls for purposes for which stone of inferior quality answers equally well, since it costs less than the other at Little Falls, because of its nearness.

The syenite has also been quarried for building stone near Little Falls. It supplies only a local use and mainly for rough work. The excessive jointing is a defect, in that very large blocks can not be procured, but, on the other hand, it vastly diminishes the expense of quarrying. The stone is for many purposes an excellent one, much of it is of good quality, the supply is ample for all local use, and, since it is the only locality in the valley where a crystalline rock suitable for building purposes occurs, a future demand for it will inevitably arise.

Road metal. There is an inexhahustible amount of good road material to be obtained within the area covered by the map, and, as road improvement is likely to be a matter of the near future, this is a fact of considerable importance. The pre-Cambrian rocks furnish the best material, but the Lowville and Trenton limestones also afford excellent stone for the purpose.

The big diabase dike which cuts the syenite just east of Little Falls on the north side of the river, is the best source of road metal in the district from the standpoint of quality, and, since the dike is over 100 feet wide, the amount available is not small. Since also the adjacent syenite is nearly as well adapted to the purpose as the diabase, there need be no careful separation of the two in working out the material at the edge of the dike.

Next to the diabase the syenite is the best road metal rock in the district. Near the depot at Little Falls the syenite is all cut up by a fine grained, red rock of granitic make-up (an aplite), which is so rich in quartz as to be a rather poor road rock. But the cliffs to the eastward show but little of this rock, so that there is a large quantity of excellent and easily accessible material.

The rock at Middleville would be equally good for the purpose, but the quantity in sight above the level of the creek is very small.

Much of the pre-Cambrian rock to the north would also serve the purpose well. The syenite gneiss is best, while the red granite gneiss and the light colored, Grenville quartz gneisses are not well adapted and should not be used.

Next to the pre-Cambrian rocks the black, slaty limestones of the passage beds afford the best road material, and have already been somewhat used for the purpose in the district. The main objection to their use is expense in quarrying, since the shale partings must be rejected, and these constitute half the bulk of the rock.

Both the Lowville and Trenton limestones will furnish an acceptable road metal, the former better than the latter. The Beekmantown rocks are in general too sandy, and much inferior to any of the foregoing.

The advantage of the pre-Cambrian rocks over the limestones is in their superior durability, along with sufficiently good binding power. But the work must be done with much more care in order to produce satisfactory results, and where this can not be done, the limestone is the preferable material.

Clays. Use has been made of the clays in but one locality, A. C. Kayser manufacturing brick from a clay bed just out of Dolgeville to the west.[1] There would seem no good reason why an excellent quality of common brick, and tile also, should not be manufactured from the laminated clays in several localities, provided exploitation shows the clay present in sufficient quantity, as is in all likelihood the case.

Sand and gravel. There is a great abundance of both these materials for all possible uses, both in the Mohawk valley and also along the line of the great moraine which follows rather closely the pre-Cambrian boundary.

Salisbury iron mine. The only locality within the sheet limits at which iron ore has been found in anything like workable quantity, is at the above mine, 2 miles north of Salisbury Center. Considerable ore has been obtained at this location, some quite

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[1] Ries, H. N. Y. State Mus. Bul. 35, p.713.

recently. But at the time of the writer's visit work was not in progress and no very satisfactory observations could be made.[1] The working is in the nature of a pit with a maximum depth of some 80 feet, the sides are perpendicular, there was some 20 feet of water at the bottom, and adjacent surface exposures are of the most meager description, so that information must be sought from either the inaccessible sides of the pit, or else from the dumps.

The main pit is from 25 to 30 yards long, from 3 to 4 yards wide, and bears nearly east and west. The dip is to the south and very steep, some 75° to 80°. The pay streak was evidently lens-shaped, pinching out at the two ends of the pit, and nothing could be learned regarding its exact size, or the purity of the ore. To the west no rock shows in outcrop, but to the east, after a 10 yard gap with no exposures but in which the ore had evidently pinched out, is another opening showing a much narrower ore body, beginning with a width of 6 inches and widening to 3 feet. Apparently mining here was never profitable, as the opening is very shallow. At the extreme east end the ore again pinches out and beyond occurs only in small, interrupted masses.

Practically the only rock outcrops are those of the vertical walls of the pit. Little pure ore was found on the dumps, but much lean ore was there, consisting largely of what must have been the immediate wall rock, a very basic hornblende gneiss. This is found to pass into a gneissoid syenite, all intermediate gradations being found. The syenite shows a local phase characterized by abundant mica (biotite) which is unlike any other rock of the district. The ordinary syenite passes into a very quartzose syenite, which is full of quartz and pegmatite veins.

A short distance north of the main pit is a low rock knoll, exposing a well banded, rusty gneiss, full of quartz veins, from which no fresh material could be obtained, and whose precise nature is uncertain, though it much resembles the acid phase of the syenite mentioned above. Near the narrow opening a basic,

[1] Since then, some farther exploitation has been done but no opportunity to revisit has occurred

garnetiferous gneiss outcrops, whose relationships are also uncertain.

One quarter mile to the eastward, along the strike, are outcrops of apparent syenite gneiss, but just north, massive ridges of Grenville gneisses cut it out, and just south are granites and dubious gneisses which are certainly not referable to the syenite, so that we are dealing here with an exceedingly small syenite intrusion, if it really be that rock.

The ore itself is of the platy sort, rather than of the granular crystalline character of much of the magnetite of the eastern Adirondacks. In this respect it is like much of the Franklin county ore. Now, while the writer has had no opportunity carefully to investigate these ores, the small study that he has been able to give them leads to the belief that many of them are of igneous origin, being basic segregations from the syenite magna, just as the titaniferous magnetites are segregations from the anorthosite. But, whereas ores of the sort are quite customarily developed in gabbro intrusions, they have been seldom noted in syenites, so that the matter requires thorough investigation, and the statement of origin is only tentatively advanced. The Salisbury ore also seems to fall into the same class, but, because of the poor exposures and the very small size of the mass of apparent syenite, the writer rather hesitates to advance the idea, though himself rather confident of its verity. If the mass be a result of differentiation in an intrusive, it is remarkable, not only because of the kind of rock involved, but also because of the great amount of differentiation in a very small eruptive mass. The thin sections seem to bear out the idea of the igneous nature of the whole, as will be shown later.

PETROGRAPHY OF THE PRE-CAMBRIAN ROCKS

Grenville rocks. These are old aqueous rocks which have been so excessively metamorphosed as to have become entirely recrystallized, with loss of all original structures, so that the main argument for their origin is that based on composition. As occurring in the district, they consisted mainly of shales and

shaly sandstones, limestone being absent. These are now gneisses of various colors, from white to black, nearly always containing pink garnets, and with the darker varieties often holding graphite as well.

What are supposed to have been shaly sandstones are now white to gray, or greenish gray, gneisses, which are rather well banded, thus hinting at a sedimentary structure due to variation in composition of different layers. If this banding does represent original bedding, then the present foliation conforms in direction with it.

To the eye these light colored gneisses appear very quartzose, but the microscope dispels the impression. No case has been observed in which the quartz constitutes so much as 50% of the rock. It commonly runs from 30% to 40%, seeming always somewhat subordinate to the feldspar in amount, the ratio between the two varying from 3 : 5 to 4 : 5. Most of the feldspar appears to be anorthoclase, as indicated by its faintly moiré appearance, but often a very considerable percentage of an acid plagioclase (apparently between albite and oligoclase) is present in addition. Other minerals than quartz and feldspar seldom constitute as much as 10% of the rock and often fall below 5%. Minute zircons usually occur in considerable number, so much so as to form a prominent feature of these Grenville rocks. Small garnets are frequent. A little biotite, a little magnetite and an occasional titanite are the other customary minerals. The silica percentage must lie above 75% in all cases, and it is believed that chemical analyses would point strongly toward a sedimentary origin for the rock, as suggested by its mineralogy and appearance.

These quartzose gneisses contain bands of somewhat more basic character, which differ from them mainly in the larger content of garnet and biotite, and in usually holding graphite in addition, mostly in minute scales and in no great quantity. One large garnet was noted full of inclusions of a green spinel, probably pleonaste. The minerals other than quartz and feldspar make from 15% to 20% of the rock. The quartz percentage is nearly or

quite as high as in the more acid gneisses, the basic minerals increasing at the expense of the feldspar.

There is also much of a more basic, heavily garnetiferous rock interbanded with the lighter colored one. Its mineralogy is much the same as that of the white gneisses in respect to the minerals present, but there is a great change in quantity. There are the same abundant small zircons, quite a little graphite, pyrite and apatite are present, a little magnetite, quite a lot of biotite and abundant garnet. All together these make from 30% to 50% of the rock, garnet alone constituting from 20 to 30%. The remainder of the rock is made up of feldspar, nearly all of which is microperthite, only a little acid plagioclase being present. The rock is practically free from quartz, all there is being found as inclusions in the large garnets. It would seem to have the composition of a calcareous shale, yet is not at all the sort of rock customarily produced from such shales by metamorphism, as amphibole of some sort usually develops in quantity. In fact, the rock may not have been calcareous, since, if present, the lime is now in the garnet, and it has not been analyzed. If it be a lime garnet the deep seated conditions prevailing during metamorphism may account for the character of the rock.

There is another variety of the above rocks which is characterized by abundant pyrite, roughly some 5%. It also has a considerable quartz content, some 25%, and more than half of the feldspar is plagioclase, an acid oligoclase with maximum extinctions of 10°. There is also considerable of a thoroughly rotted bisilicate. Biotite is present in large quantity and garnets are sparing or absent. With pyrite decay the rock weathers rusty. All sorts of gradations between all these types occur, but taken as a whole they characterize the sedimentary Grenville of the district.

Along with the foregoing are occasional bands of a rusty weathering gneiss which, when fresh, is seen to be thoroughly gneissoid, foliae of glassy quartz grains alternating with black leaves of more basic mineral fragments, the whole making a rather dark colored rock. Yet it shows a higher quartz content than any other, that mineral making fully two thirds of the rock. It is of

coarse grain but not of the leaf type, and holds a multitude of inclusions of the other minerals, along with a little apatite and many zircons. Except for these inclusions the quartz foliae are entirely of that mineral.

Between is a mosaic of garnet, augite, bronzite and feldspar, with many minute graphite scales. Oligoclase is the prevailing feldspar, though with anorthoclase also. Notwithstanding the high quartz content, the rock holds more lime and magnesia than any of those already mentioned and would seem to have been a calcareous sandstone. It grades into less quartzose varieties.

Associated igneous gneisses. Mingled with the Grenville sediments, often intricately, are other gneisses, some of doubtful, and some of pretty distinctly igneous character. These rocks are always thoroughly gneissoid, retaining no more trace of their original texture than is the case with the old sediments, so that again the argument for their origin is mainly based on their composition. The dubious rocks are of so many sorts and shades that it is difficult to treat of them except in a mass of details which would be out of place here. Some of them may likely be foliated contact rocks, and others may be due to a development of mixed rocks along the contacts of the aqueous and igneous rocks by an interchange of materials during metamorphism, though it is not at all certain that such transference ever takes place to any important extent, even during very deep seated metamorphism.

The probable igneous rocks show a range from the most acid granites through syenitic rocks to heavy, black rocks of gabbroic composition.

The granitic gneisses are usually of red color and mainly composed of quartz and feldspar, the gneissoid character being dependent on the development of quartz of the leaf type in thin foliae, separated by fine quartz feldspar mosaic. The quartz makes from one quarter to one half of the rock, the feldspar is mainly anorthoclase or microperthite, though with some oligoclase always, and sometimes a little microcline, and the other constituents are small amounts of zircon, apatite, magnetite and

biotite, with sometimes hornblende also. These taken together often constitute no more than 5% of the rock, and seldom exceed 10%. There are occasional coarser feldspar fragments present which may represent crystal remnants of the original rock that have escaped the prevailing recrystallization.

The syenites are gray to greenish gray rocks, commonly rather quartzose, which approach granites on the one hand and gabbros on the other. Except for their close association with the Grenville sediments, they are not to be distinguished from the thoroughly gneissoid phases of the later syenite, whose description will serve equally for them.

The original gabbros are now converted into hornblende or pyroxene gneisses. On the one hand, are hornblende, biotite, plagioclase gneisses; on the other, augite and bronzite (or hypersthene) appear instead of hornblende. In the pyroxene gneisses garnet often occurs, magnetite always and pyrite sometimes. The feldspar ranges from andesin to labradorite; but not infrequently a large part of it is not plagioclase at all but of intergrowths, either of microperthitic or of micrographic habit, and such portion may make more than 50% of the whole, giving the rock more of a monzonitic than of a gabbroic make-up.

Syenite gneiss. The area given the syenite coloration in the northeast portion of the geologic map is constituted of quite homogeneous rocks, of thoroughly gneissoid character, gray to greenish gray color, rapidly weathering brown, and of syenitic make-up. They vary somewhat in coarseness of grain and considerably in their quartz percentage, some of them being very acid. There are occasionally to be seen slightly larger feldspar fragments which seem to be of the nature of augen, and around which traces of cataclastic structure appear. But these are small fragments at best, the structure traces are obscure, and the evidence of igneous origin from this standpoint very slender. If, however, the writer be correct in referring the augen character of the syenite at Little Falls to an original porphyritic structure in the rock, then the absence of that character here may have no

further significance than to denote the original lack of that structure.

The rock is composed of quartz and feldspar with varying amounts of biotite, augite, bronzite and hornblende, and with magnetite, apatite, zircon, and a little occasional titanite as accessories.

The quartz content ranges from 5% to 25%. It is evidently all recrystallized and commonly of coarser grain than the other minerals, though never prominently of the leaf type. Its increase in amount is accompanied by diminution of the dark silicate content, specially of the augite and bronzite.

Feldspar makes from 65% to 85% of the rock. It is mostly of faintly moiré appearance, seldom well marked microperthite, and is presumably anorthoclase. But some oligoclase is always present as well, usually in small amount, but rising to as high as 25% of all feldspar present. The mineral is usually in equidimensional grains, constituting a fine mosaic, and, except for an occasional larger individual with traces of cataclastic structure, seems to have been wholly recrystallized. The larger fragments are usually of well marked microperthite.

Biotite is the most constant of the dark silicates, occurring in nearly all varieties of the rock, and being practically the only one to persist in the more acid varieties. Bronzite is perhaps next in abundance. Sometimes all four (bronzite, augite, hornblende and biotite) are present, and then biotite plays a subordinate role. Including magnetite these minerals never make more than 15% of the rock, and in the quartzose members may fall below 5%.

Rocks at the Salisbury iron mine. *Ore.* The thin section of the purest ore which the writer could find on the dumps shows the presence of many inclusions of other minerals, though indicating that these are not present to the amount of more than 15% to 20%, and hence that the ore is rich, though there is nothing to show how large a proportion has this character. Professor E. W. Morley was so good as to make a test of the ore for titanium, his

result proving that the ore is not titaniferous to any appreciable extent, the figures being certainly under .5%.

The inclusions are of apatite, augite and quartz. The two former are numerous, though rather small, have good idiomorphic boundaries against the magnetite, specially in the case of the apatite, which clearly formed before the magnetite, as did apparently some of the smaller augites also. The augite is of pale green color, without pleochroism, exactly like that of the wall rock.

The quartz inclusions are of much interest. They are of the elongated leaf or spindle shape, like the quartz of the inclosing gneisses, and some of them are of large size. Polarized light shows that they are composed of a much greater number of separate mineral fragments than usual, and all show strong undulatory extinction. Around many of them is a zone, or rim, of finely crystalline augite. These rims are also duplicated in some of the inclosing gneisses and seem clearly due to reaction between the magnetite and quartz. In the gneisses they only form between magnetite and quartz. They are exceedingly like the augite rims which form about quartz inclosures in basic igneous rocks. Why they do not occur about all the quartzes is a puzzle. The writer is disposed to regard the presence of the quartz in the ore as due to metamorphism and attendant recrystallization, whence it would follow that the rims formed as a result of the same process.

Walls. Inclosing the ore, and grading into it, is a very basic gneiss composed of hornblende, magnetite, augite, feldspar and quartz, the black minerals constituting 75% of the rock. Hornblende is much the most abundant of these. About equal amounts of quartz and feldspar are present, the feldspar being part oligoclase and part anorthoclase.

So far as can be judged from specimens obtained from the dumps, this gneiss grades rapidly into a more feldspathic hornblende gneiss, and the latter into a syenite gneiss, at first basic but rapidly becoming more acid.

The more basic rock shows abundance of fairly coarse hypersthene, which is platy, lies in the foliation planes, gives the rock a

green and black mottled aspect, and seems certainly secondary and formed during metamorphism. There is considerable magnetite in the rock, which shows augite rims wherever it is in contact with quartz and also around the small quartz inclusions. A little biotite and green hornblende are present, and considerable apatite, the latter often of large size and full of black, dustlike inclusions. The feldspar is mostly anorthoclase, though quite a bit of oligoclase is present. There are some larger feldspars which seem to have escaped recrystallization, and these are microperthite. Quartz is but sparingly present, mostly in coarse leaves, though also as inclusions in the coarse hypersthenes and magnetites. It is present to the amount of some 5% only, while feldspar constitutes from 65% to 70%.

The rock seems to be igneous and to be a syenite, though with peculiarities. Except for some possible small amounts of feldspar, magnetite and apatite, it seems to have undergone complete recrystallization. In many respects, notably in the augite rims, it is peculiar and affiliated with the ore.

The last rock of the series strongly resembles the acid variety of the ordinary syenite gneiss of the region. It is mainly a feldspar quartz rock. In addition are numerous small zircons and a little apatite, biotite, magnetite and hornblende, all together not constituting over 5% of rock. The feldspar is mostly anorthoclase, though with a little oligoclase in addition. The quartz forms some 20% of the rock and is mainly in rather coarse leaves. The rock is wholly recrystallized, but has syenite composition.

We seem here to be clearly dealing with a basic segregation in a rather acid rock of probable igneous origin. But the exposures are so poor, and the whole series so metamorphosed that no decisive evidence is forthcoming in regard to the origin of the ore. While it seems not unlikely that it may represent an original basic segregation from the cooling intrusive, analogous to the titaniferous ores of the gabbroic intrusives of the region, the evidence is far too meagre to warrant a definite pronouncement in favor of this mode of origin. The ore may equally as well owe its existence to secondary processes.

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Museum bulletin 70

3 New York Mineral Localities

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New York State Museum

Frederick J. H. Merrill Director

Bulletin 70

MINERALOGY 3

LIST OF

NEW YORK MINERAL LOCALITIES

BY

H. P. WHITLOCK C. E.

New York State Museum

FREDERICK J. H. MERRILL Director

Bulletin 70

MINERALOGY 3

LIST OF

NEW YORK MINERAL LOCALITIES

PREFACE

The lack of systematic classification and of accurate geographic and geologic location of the many mineral localities of New York State, which so materially hampers a detailed study of any mineral collection, has suggested the preparation of a list of the recorded localities for mineral specimens in New York State, which is offered to the public in the following bulletin. The kindly reception accorded to the previous publications of this division of the New York State Museum has led to the hope that the present bulletin will meet a material want not only as a curatorial aid to museum workers in mineralogy in furthering a more accurate labeling of New York specimens but also as a guide to collectors, teachers and students in their field excursions.

The data have been largely compiled from the mineralogic and geologic publications given in the bibliography and have, in a number of cases, been added to, checked and modified by field notes and by the study of specimens from the collections mentioned in the list of authorities. Such a list must, from its character, be incomplete in many points and the author would gladly welcome any information which would render a subsequent edition more comprehensive and accurate.

The author is indebted to Dr F. J. H. Merrill, state geologist, for many valuable suggestions regarding the general character of the work and for much of the geographic and geologic informa-

tion embodied in the text. Acknowledgment is also tendered to the gentlemen whose names appear in the list of authorities for local information.

RELATIONS OF MINERAL DEPOSITS TO ROCKS

By far the greater part of the crystallized minerals of New York State occur in igneous and metamorphic rocks, or grouping these two divisions in a rather broader term, in crystalline rocks. The areas covered by these embrace two important sections of the State; the northern section including the Adirondack region and extending over St Lawrence, Jefferson and Lewis counties on the west and the southeastern section including New York, Westchester, Putnam and portions of Orange, Rockland, Richmond and Dutchess counties. The area of Silurian limestones, extending from west to east across the State just south of Lake Ontario and trending to the south along the west shore of the Hudson, affords many localites for secondary minerals notably calcite, dolomite, celestite, barite, quartz etc.

Igneous rocks

Granites and pegmatites. The component and accessory minerals of granite are commonly found in independent well formed individuals in cavities or vugs where the open space admits of free development of crystals formed by the separation of the mineral constituents from the fused rock magma in the process of its solidification. Pegmatite occurring in dikes and veins is characterized by the same genetic series of minerals found in granite but commonly in rather larger individuals corresponding to the coarser structure of the rock.

COMMON MINERALS FORMING AND OCCURRING IN GRANITE AND PEGMATITE

pyrite	microcline	epidote
marcasite	oligoclase	allanite
quartz	spodumene	tourmalin
corundum	amphibole	muscovite
chrysoberyl	beryl	biotite
rutile	garnet	titanite
orthoclase	zircon	xenotime
albite	topaz	apatite

Gabbros, diorites and other basic igneous rocks. Rocks of this series have for their chief feldspar constituents the plagioclases; both orthorhombic and monoclinic pyroxenes occur as component minerals. The formation of individual crystals takes place as the rock grades from finer to coarser structure and gives rise to strings or zones of crystallized minerals rather than pockets and cavities as is the case with granite.

COMMON MINERALS FOUND IN BASIC IGNEOUS ROCKS

magnetite	labradorite	garnet
ilmenite	enstatite	biotite
spinel	hypersthene	chrysolite
albite	pyroxene	titanite
anorthite		

Metamorphic rocks

Gneisses. Typical gneiss differs but little in mineralogic composition from typical granite. The mineral constituents are, however, to be found in larger and better formed individuals along zones of contact with crystalline limestone and local areas of magmatic segregation.

COMMON MINERALS FOUND IN GNEISS

graphite	hematite	sillimanite
chalcopyrite	orthoclase	cyanite
pyrite	albite	allanite
marcasite	amphibole	tourmalin
quartz	pyroxene	staurolite
corundum	garnet	muscovite
spinel	vesuvianite	biotite
magnetite	zircon	monazite
rutile	andalusite	apatite

Crystalline limestones. The crystalline limestones are prolific in accessory minerals which occur disseminated through the mass of the rock, in pockets or vugs or in zones of contact between the limestone and an adjacent igneous intrusive rock.

COMMON MINERALS FOUND IN CRYSTALLINE LIMESTONES

graphite	dolomite	garnet
sphalerite	siderite	titanite
pyrite	pyroxene	tourmalin
marcasite	wollastonite	chrysolite
quartz	amphibole	humite group
corundum	wernerite	muscovite
spinel	vesuvianite	phlogopite
rutile	zircon	clinochlore
brucite	danburite	talc
calcite	epidote	apatite

Crystalline schists. A characteristic series of minerals, for the most part silicates, is found in micaceous, hornblendic and argillaceous schists. They occur embedded and disseminated through the mass of the rock and reach their highest development along the contact portion of the rock mass.

COMMON MINERALS FOUND IN CRYSTALLINE SCHISTS

quartz	cyanite	biotite
chrysoberyl	andalusite	iolite
amphibole	sillimanite	tourmalin
garnet	staurolite	beryl
zircon	muscovite	

Serpentines and talc. The minerals occurring in serpentine are in some cases the unaltered species from which the serpentine was derived, in other cases secondary minerals resulting from a further alteration of the serpentine. They occur embedded and in veins of various thickness traversing the serpentine masses.

COMMON MINERALS FOUND IN SERPENTINE AND TALC

quartz (chalcedony)	magnesite	garnet
spinel	enstatite	clinochlore
chromite	pyroxene	talc
brucite	amphibole	deweylite
dolomite	chrysolite	apatite
calcite		

Secondary minerals

Secondary minerals, developed as a result of chemical action on previously formed rocks, are, to a large extent, deposited by percolating water. With regard to their mode of occurrence they may be classified as follows: (1) concretions; (2) deposits lining the interior of cavities, vugs, caverns and grottos; (3) vein formations; (4) minerals produced through pseudomorphism and paramorphism.

Concretions. Concretionary deposits of mineral matter are frequent in rocks of sedimentary origin. They are in general formed by the deposition, in successive layers around some organic center, of mineral matter leached from the surrounding rock. The calcium carbonate concretions found in clay beds are excellent types of this form of mineral occurrence. Concretionary forms of quartz, siderite, pyrite, chalcocite etc., are also formed in sedimentary rocks.

Deposits lining the interior of cavities, etc. The formation of secondary minerals in cavities of various origin results from the chemical action of percolating water on the rock adjacent to and forming the walls of the cavity. The soluble mineral matter is dissolved from the rock traversed by the descending surface water to be redeposited, sometimes in an entirely different form in the open spaces. The minerals thus deposited take the form of distinct crystallizations or of concentric, incrusting masses.

COMMON SECONDARY MINERALS OCCURRING IN CAVITIES

hematite	barite	apophyllite
limonite	celestite	stilbite
quartz	anhydrite	chabazite
calcite	gypsum	heulandite
dolomite	serpentine	harmotome
siderite	sulfur	analcite
aragonite	datolite	natrolite
strontianite	prehnite	

Vein formations.[1] Mineral veins may, with justice, be considered as constituting a division under the last named class of secondary mineral deposits; the distinctive character of the

[1] The formation of mineral veins has been very fully discussed by Posepny, F. Genesis of Ore Deposits. Am. Inst. Min. Eng. Trans. 1893. p. 23–197.

minerals found in veins has, however, led the author to consider them under a separate head. The large and important group of vein minerals includes most of the ores of commercial importance, particularly the metallic sulfids and sulfosalts.

VEIN MINERALS OF COMMON OCCURRENCE IN NEW YORK STATE

galena	fluorite	dolomite
sphalerite	quartz	siderite
millerite	cuprite	strontianite
pyrrhotite	hematite	orthoclase
chalcopyrite	magnetite	prochlorite
pyrite	rutile	barite
marcasite	brucite	celestite
arsenopyrite	calcite	gypsum

Minerals produced through pseudomorphism and paramorphism. Minerals included in this group are alteration products of primary minerals. These, while retaining the external form of the primary minerals, from which they were derived, differ essentially from them in composition.

Drift boulders

Transported masses of rock are found in all parts of New York State, frequently in boulders of considerable size. These are fragments of rock which, through action of glacial or fluvial erosion and transportation have been torn from their parent outcrops and have been carried, generally to the south and east of their original sources. The distance which the drift boulder may have been carried by the ice sheet in the glacial period varies widely so that no accurate estimate can be made of the distance between any glacial fragment and its parent mass.

SOURCES AVAILABLE FOR COLLECTING MINERAL SPECIMENS

The sources available for the collection of mineral specimens may be classified as follows:

Sources	natural	surface outcrops
		drift boulders
		caves
	artificial	mines and quarries
		excavations for construction: foundations of buildings, sewers, subways
		prospects

Surface outcrops. The surface outcrops of rocks of all formations but particularly unstratified rocks may be studied with considerable profit by the mineral collector in search of specimens. A judicious use of the hammer and cold chisel will often expose, under an unpromising cluster of weathered and decomposed crystals, fresh material well worth the labor expended on its development. The precipitous faces of cliffs and escarpments, furnish in some cases profitable sources for the collection of specimens.

Drift boulders and fragments. While in some instances drift boulders, notably those composed of crystalline rock, are valuable sources of mineral specimens the uncertainty regarding the original locality from which they were derived tends to render questionable the value of such specimens. A source of mineral material which may be classed under this head and which is often of more value than drift fragments embedded in the soil is the fragmental rock material used in the construction of stone walls. The accessibility of these to the roads and the comparative ease with which their component fragments may be identified with the country rock should not be overlooked by the collector particularly in a region of crystalline schists.

Natural caves. Subterranean tunnels and caverns, formed principally in limestones by the mechanical and chemical erosion of underground waters, frequently become repositories for secondary minerals deposited on the sides and roof as a result of the leaching action of percolating surface water. The exploration of these natural caves often results in the discovery of beautiful crystallizations which from the nature of their deposition are readily detachable.

Mines and quarries. Probably nowhere is the mineral collector better repaid for his trouble than in exploring the dump heap of a mine. The waste material representing, as most of it does, the contents of the contact zone between the vein or ore body and the country rock is usually rich in ore minerals as well as in crystallizations of accessory minerals from the country rock. Similarly but to a somewhat less extent the rejected material from a granite or limestone quarry is a profitable collecting source.

Excavations for building and improvements. From the casual manner in which these workings penetrate rock formations with respect to productive mineral zones they are hardly calculated to furnish the wealth of mineral specimens met with in mining and quarrying operations. It is, however, true that many rich finds such as, for example, the dumortierite of New York island have resulted from excavations for foundations of buildings, sewer diggings and other municipal improvement works. The accessibility of these excavations to the centers of population often results in a more careful study of the excavated material and in the finding of obscure mineral occurrences which might otherwise escape notice. Rocks exposed in railroad cuts and tunnels may also be said to constitute an important subclass under this head and possess the added advantage of being permanently available for collecting purposes.

Prospects. The use of rudimentary mining tools and methods is of considerable value in the acquiring of mineral specimens particularly in regions where mining and quarrying operations are not generally pursued. In most cases a knowledge of the prevailing dip and strike of the country rocks and of the location of the zones of contact between their strata will enable the collector to reach with the aid of a pick and shovel points where the component and accessory minerals occur in well crystallized aggregates. In some cases a blast exploded in a properly drilled hole will amply repay for the expense and trouble incurred, but of course such procedure should be attended with the greatest caution.

EXPLANATION OF LIST

In the following tabulated list of localities the first and fifth columns contain the numbers which have been assigned to each locality in order to furnish a ready and convenient means of reference. The second column gives with as much detail as is available the geographic position of the localities grouped under counties and towns. As far as possible definite geographic locations have been substituted for old names of farms, etc.; it has been the author's experience that it is at present extremely difficult to locate the original mineral locality by the old farm name. The third column gives a list of the mineral species

occurring at each locality. The fourth column contains descriptive notes regarding such crystallographic, structural, or other features as may be characteristic of the mineral occurrence. The sixth column is reserved for a quality mark which is assigned to certain occurrences to indicate the mineralogic quality or commercial importance of the material as follows:

xx indicates very fine specimens
x indicates fine specimens
* indicates that the mineral has been mined or quarried
† indicates that the mines or quarries are no longer operated

The absence of any of the above symbols in the sixth column opposite any given species indicates the occurrence of specimens of ordinary grade.

In the seventh column is noted the character of the rock in which the mineral species occurs, this in many cases being common to all the species found in any locality.

The eighth column contains a list of the mineral species associated with the mineral noted in the third column. This in many instances constitutes a genetic association which is of interest from the standpoint of the formation of minerals.

The numbers and letters given in the ninth column refer to the published and unpublished authorities as given in the following bibliography and list of unpublished authorities.

BIBLIOGRAPHY

1 **Akerly, Samuel.** On the Geology and Mineralogy of the Island of New York. Am. Min. Jour. 1814. 1:191.

2 **Bailey, S. C. H.** On the Minerals of New York Island. N. Y. Lyceum Nat. Hist. Ann. Nov. 1865. v. 8.

3 **Beck, L. C.** Report on the Mineralogical and Chemical Departments of the N. Y. Mineralogical and Geological Survey. N. Y. Min. Rep't. 1837. p. 17; 1838. p. 7; 1839. p. 9.

4 ——— The Mineralogy of N. Y. State by Counties. N. Y. Min. Rep't. 1840. p. 54.

5 ——— Mineralogy of New York. 1842.

6 ——— Analysis of Hypersthene of New York. Am. Jour. Sci. Ser. 1. 1843. 44:35.

7 ——— Analysis of Allanite of Monroe, N. Y. Am. Jour. Sci. Ser. 1. 1843. 44:37.

8 ——— Notices of some Trappean Minerals in New Jersey and New York. Am. Jour. Sci. Ser. 1. 1843. 44:54

9 **Beck, L. C.** Mineralogy of New York. Am. Jour. Sci. Ser. 1. 1844. 46:25.

10 **Bergemann, C.** Allanite from West Point. Am. Jour. Sci. Ser. 2. 1852. 13:416.

11 **Blake, W. P.** On a Method for Distinguishing between Biaxial and Uniaxial Crystals when in Thin Plates,— and the Results of the Examination of Several Supposed Uniaxial Micas. Am. Jour. Sci. Ser. 2. 1851. 12:6.

12 ——— Lanthanite and Allanite in Essex County, N. Y. Am. Jour. Sci. Ser. 2. 1858. 26:245.

13 **Bishop, I. P.** Structural and Economic Geology of Erie County. N. Y. State Mus. 49th An. Rep't. 1898. 2:305–92.

14 **Blum, J. R.** The Alteration of Pyroxene to Mica. Pseudomorphosen 3d nachtrag. 1843. p. 163; 1863. p. 93.

15 **Brewer, W. H.** Analysis of Pyroxene from Edenville. Liebig's-Kopp's Jahresber. 1850. p. 712.

16 **Breidenbaugh, E. S.** On the Minerals found at the Tilly Foster Iron Mines. N. Y. Am. Jour. Sci. Ser. 3. 1873. 6:207.

17 **Brigham, A. P.** Drift Boulders between the Mohawk and Susquehanna Rivers. Am. Jour. Sci. Ser. 3. 1895. 49:213.

18 **Britton, N. L.** Geology of Richmond County. N. Y. Acad. Sci. Ann. 2:161.

19 **Bruce, A.** White Pyroxene from New York Island. Bruce's Min. Jour. 1814. p. 266.

20 **Brush, G. J.** On Chalcodite. Am. Jour. Sci. Ser. 2. 1858. 25:198.

21 ——— Mineralogical Notices. Am. Jour. Sci. Ser. 2. 1858. 26:64.

22 ——— & **Dana, E. S.** Crystallized Danburite from Russell, St Lawrence County, N. Y. Am. Jour. Sci. Ser. 3. 1880. 20:111.

23 **Chamberlin, B. B.** Minerals of Staten Island. N. Y. Acad. Sci. Trans. 1887. 5:228.

24 **Chester, A. H.** Mineralogical notes. Am. Jour. Sci. Ser. 3. 1887. 33:283.

25 **Clarke, F. W.** Constitution of Tourmaline. Am. Jour. Sci. Ser. 4. 1899 8:111.

26 ——— & **Schneider, E. A.** Constitution of the Natural Silicates; the Micas. Am. Jour. Sci. Ser. 3. 1890. 40:410.

27 **Cleveland, Parker.** Mineralogy. Bost. 1822.

28 **Cozzens, Issachar.** Geological History of Manhattan Island. New York. 1843.

29 **Craw, W. J.** Analysis of Phlogopite from St Lawrence County, N. Y. Am. Jour. Sci. Ser. 2. 1850. 10:383.

30 **Crawe, J. B. & Gray, Asa.** Sketch of the Mineralogy of a portion of Jefferson and St Lawrence Counties. Am. Jour. Sci. Ser. 1. 1834. 25:346.

31 **Cushing, H. P.** Preliminary Report on the Geology of Clinton County. N. Y. State Mus. 47th An. Rep't. 1894. p. 667–83.

32 ——— Report on the Geology of Clinton County. N. Y. State Mus. 49th An. Rep't. 1898. 2:21–22; 499–573.

33 ——— Preliminary Report on the Geology of Franklin County. N. Y. State Mus. 52d An. Rep't. 1900. 2:75.

34 **Cushing, H. P.** Geology of Rand Hill and Vicinity. N. Y. State Mus. 53d An. Rep't. 1901. 1:r37–82.

35 **Cutbush, Dr.** Localities of Minerals near West Point. Am. Jour. Sci. Ser. 1. 1824. 7:57.

36 **Dana, E. S.** Preliminary Notice of Chondrodite Crystals from the Tilly Foster Mine, Brewster, N. Y. Am. Jour. Sci. Ser. 3. 1875. 9:63.

37 ——— On the Chondrodite from the Tilly Foster Mine, Brewster, N. Y. Am. Jour. Sci. Ser. 3. 1875. 10:89.

38 ——— On the Optical Character of Chondrodite of the Tilly Foster Mine. Am Jour. Sci. Ser. 3. 1876. 11:139.

39 ——— On a Crystal of Allanite from Port Henry, N. Y. Am. Jour. Sci. Ser. 3. 1884. 29:479.

40 **Dana, J. D.** Note on Hudsonite. Am. Jour. Sci. Ser. 2. 1855. 19:362.

41 ——— Leucaugite from Amity, N. Y. Am. Jour. Sci. Ser. 3. 1873. 6:24.

42 ——— On Serpentine Pseudomorphs and other kinds from the Tilly Foster Iron Mine, Putnam County, N. Y. Am. Jour. Sci. Ser. 3. 1874. 8:371, 447.

43 ——— System of Mineralogy. Ed. 5, 1868; Ed. 6, 1892.

44 ——— On the Geological Relations of the Limestone Belts of Westchester County. Am. Jour. Sci. Ser. 3. 1880. 20:21, 194, 359, 450; Ser. 3. 1881. 21:425; Ser. 3. 1881. 22:1, 104; Ser. 3. 1881. 22:313, 327.

45 ——— Note on the Cortlandt and Stony Point Hornblendic and Augite Rocks. Am. Jour. Sci. Ser. 3. 1884. 28:384.

46 **Darton, N. H.** Mineralogical Localities in and around N. Y. City and their Minerals. Sci. Am. Sup. 1882. 14:5492, 5566, 5796; 1883. 16:6629.

47 ——— Preliminary Description of the Faulted Region of Herkimer, Fulton, Montgomery and Saratoga Counties. N. Y. State Mus. 48th An. Rep't. 1897. 2:33.

48 **Des Cloiseaux, A.** Manuel de mineralogie. Paris. v. 1, 1862; v. 2, 1874.

49 **Diller, J. S. & Whitfield, J. E.** Dumortierite from Harlem, N. Y., and from Arizona. Am. Jour. Sci. Ser. 3. 1884. 37:216.

50 **Doelter, C.** Ueber Diopsid. Tscher. Min. Mitth. N. F. 1:55.

51 ——— Diopside from Greenwood Furnace. Tscher. Min. Mitth. 1887. p. 286.

52 **Eakle, A. S.** On some Dikes occurring near Lyon Mt, Clinton County, N. Y. Am. Geol. July 1893. p. 7.

53 **Emmons, Ebenezer.** Strontianite discovered in the United States. Am. Jour. Sci. Ser. 1. 1835. 27:182.

54 ——— Description of Two Minerals supposed to be New. Geol. N. Y. 2d Dist. Apx. 1838.

55 **Eaton, A.** Gases, Acids and Salts, of Recent Origin and now Forming on and near the Erie Canal, N. Y. Am. Jour. Sci. Ser. 1. 1829. 15:233.

56 **Fenn, H. N.** Coal, Gypsum and Barytes near Rochester. Am. Jour. Sci. Ser. 1. 1824. 6:56.

57 **Finch, J.** Notice of the Locality of Bronzite at Amity, Orange County, N. Y. Am. Jour. Sci. Ser. 1. 1829. 16:185.

58 ——— Essay on the Mineralogy and Geology of St Lawrence County. Am. Jour. Sci. Ser. 1. 1831. 19:220.

59 **Foot, Lyman**. Notices of the Geology and Mineralogy of Niagara Falls Region. Am. Jour. Sci. Ser. 1. 1822. 4:35.

60 **Fowler, S**. An Account of some New and Extraordinary Minerals discovered at Warwick, Orange County, N. Y. Am. Jour. Sci. Ser. 1. 1829. 9:242.

61 **Friederich, J. J**. Minerals of New York, N. Y. N. Y. Acad. Sci. Trans. 1887. 6:130.

62 **Gale, L. D**. Report on the Geology of New York County. N. Y. Geol. Sur. 3d An. Rep't. 1839. p. 177–99.

63 **Gebhard, John, jr**. On the Geology and Mineralogy of Schoharie. Am. Jour. Sci. Ser. 1. 1835. 28:72.

64 **Genth, F. A**. Allanite from Orange County, N. Y. Am. Jour. Sci. Ser. 2. 1853. 16:86.

65 ——— Contributions to Mineralogy. Am. Jour. Sci. Ser. 2. 1855. 19:20.

66 **Goessman, C. A**. Contributions to the Chemistry of the Mineral Springs of Onondaga, N. Y. Am. Jour. Sci. Ser. 2. 1866. 42:211, 368.

67 **Gratacap, L. P**. Notes on the Limonite Beds on Ocean Terrace, Staten Island. Staten Island Nat. Sci. Ass'n Proc. 1899. v. 7, no. 12, p. 2.

68 **Hall, C. E**. Laurentian Magnetic Iron Ore Deposits of Northern New York. N. Y. State Geol. 4th An. Rep't. 1884. p. 23.

69 **Hawes, G. W**. Analysis of Pyroxene from Edenville, N. Y. Am. Jour. Sci. Ser. 3. 1878. 16:597.

70 **Hidden, W. E**. Xenotime from New York City. Am. Jour. Sci. Ser. 3. 1888. 36:380.

71 **Hillebrand, W. F**. Wollastonite, Oneida County, N. Y. Am. Jour. Sci. Ser. 4. 1896. 1:323.

72 **Horton, William**. Report on the Geology of Orange County. N. Y. Geol. Sur. 3d An. Rep't. 1839. p. 135.

73 ——— List of Minerals observed in Making the Examination of Orange County. Geol. N. Y. 1st Dist. 1839. p. 166.

74 ——— List of Minerals found in Orange County, N. Y. Geol. N. Y. 1st Dist. 1843. p. 577.

75 **Hough, F. B**. Observations on the Geology of Lewis County. Am. Quar. Jour. Agric. and Sci. Ser. 5. 1847. p. 267, 314.

76 ——— Mineral Localities in New York. Am. Jour. Sci. Ser. 2. 1848. 5:132.

77 ——— On the Existing Mineral Localities of Lewis, Jefferson and St Lawrence Counties, N. Y. Am. Jour. Sci. Ser. 2. 1850. 9:424.

78 ——— On the Discovery of Sulphuret of Nickel in Northern New York. Am. Jour. Sci. Ser. 2. 1850. 9:287.

79 ——— New Mineral Localities in New York. Am. Jour. Sci. Ser. 2. 1850. 9:288.

80 ——— New American Localities of Minerals. Am. Jour. Sci Ser. 2. 1851. 12:395.

81 ——— Descriptions of Mineralogical and Geological Specimens presented to the New York State Museum. N. Y. State Cab. of Nat. Hist. 4th An. Rep't. 1851. p. 82

82 **Hovey, E. O.** Notes on some Specimens of Minerals from Washington Heights, N. Y. City. Am. Mus. Nat. Hist. Bul. 1895. 7:341.

83 **Hubbard, O. P.** Geological and Mineralogical Notices (Northern New York). Am. Jour. Sci. Ser. 1. 1837. 32:230.

84 **Hunt, T. S.** On the Acid Springs and Gypsum Deposits of the Onondaga Salt Group. Am. Jour. Sci. Ser. 2. 1849. 7:175.

85 ——— Description and Analysis of a new Mineral Species containing Titanium with remarks on the constitution of titaniferous minerals. Am. Jour. Sci. Ser. 2. 1846. 2:30.

86 ——— On the Chemical Constitution of the Mineral Warwickite. Am. Jour. Sci. Ser. 2. 1851. 11:352.

87 ——— Note on the Occurrence of Glauconite in the Lower Silurian Rocks Am. Jour. Sci. Ser. 2. 1862. 33:277.

88 ——— On the Laurentian Limestones and their Mineralogy. Geol. Sur. of Can. Rep't of Progress. 1863–66. p. 181.

89 ——— Mineralogy of the Laurentian Limestones. N. Y. State Mus. 21st An. Rep't. 1871.

90 ——— Geology of Port Henry, N. Y. Can. Nat. 1883. 10:420.

91 **Jackson, C. J.** On Eupyrchroite of Crown Point, N. Y. Am. Jour. Sci. Ser. 2. 1851. 12:73.

92 **Jessup, A. E.** Geological and Mineralogical Notice of a Portion of the Northeastern Part of the State of New York. Phil. Acad. Sci. Jour. 1822. 2:185.

93 **Johnson, S. W.** On the Houghite of Prof. Shepard. Am. Jour. Sci. Ser. 2. 1851. 12:361.

94 **Julien, A. A.** On the Serpentine of Staten and New York Islands. N. Y. Acad. Sci. Trans. 1882. 1:58.

95 **Keating, W. H.** Lamellar Pyroxene from West Point, N. Y. Phil. Acad. Sci. Jour. 3:68.

96 **Kemp, J. F.** On the Rosetown Extension of the Cortlandt Series. Am. Jour. Sci. Ser. 3. 1888. 36:247.

97 ——— The Geology of Manhattan Island. N. Y. Acad. Sci. Trans. 1888. 7:49.

98 ——— Notes on the Minerals occurring near Port Henry, N. Y. Am. Jour. Sci. Ser. 3. 1890. 40:62.

99 ——— The great Shear-zone near Avalanche Lake, in the Adirondacks. Am. Jour. Sci. Ser. 3. 1892. 44:109.

100 ——— Preliminary Report on the Geology of Essex County, N. Y. N. Y. State Geol. 13th An. Rep't. 1894. 1:22, 575; N. Y. State Mus. 47th An. Rep't. 1894. p. 627.

101 ——— The Nickel Mine at Lancaster Gap, Pa., and the Pyrrhotite Deposits at Anthony's Nose, on the Hudson, N. Y. Am. Inst. Min. Eng. Trans. 1894. 24:620, 888.

102 ——— Crystalline Limestone, Ophicalcites and Associated Schists of the Eastern Adirondacks, N. Y. Geol. Soc. Am. Bul. 1895. 6:241.

103 ——— Geology of Moriah and Westport Townships, Essex County. N. Y. State Mus. Bul. 14. 1895.

104 **Kemp, J. F.** Geology of Moriah and Westport Townships, Essex County, N. Y. N. Y. State Mus. 48th An. Rep't. 1897. 1:325.

105 ——— Geology of the Lake Placid Region, N. Y. N. Y. State Mus. Bul. 21. 1898.

106 ——— Geology of the Magnetites near Port Henry, N. Y., and especially those of Mineville. Am. Inst. Min. Eng. Trans. 1898. 27:146.

107 ——— Titaniferous Iron Ores of the Adirondacks. U. S. Geol. Sur. 19th An. Rep't. 1899. 3:377.

108 ——— **& Hill, B. F.** Preliminary Report on the Precambrian Formations in parts of Warren, Saratoga, Fulton and Montgomery Counties. N. Y. State Geol. 19th An. Rep't. 1901. p. r17; N. Y. State Mus. 52d An. Rep't. 1901. p. r17.

109 ——— **& Hollick, Arthur.** Granite of Mounts Adam and Eve, Warwick, Orange County, N. Y., and its Contact Phenomena. N. Y. Acad. Sci. Ann. 7:638.

110 ——— ——— White Limestones of Orange County, N. Y. Am. Jour. Sci. Ser. 3. 1894. 47:401.

111 ——— **& Newland, D. H.** Preliminary Report on the Geology of Washington, Warren and Parts of Essex and Hamilton Counties. N. Y. State Geol. 17th An. Rep't. 1899. p. 499; N. Y. State Mus. 51st An. Rep't. 1899. 2:499.

112 ——— ——— **& Hill, B. F.** Preliminary Report on the Geology of Hamilton, Warren and Washington Counties. N. Y. State Geol. 18th An. Rep't. 1899. p. 137; N. Y. State Mus. 52d An. Rep't. 1900. 2:137.

113 **Kenngott, A. G.** Note on Hudsonite. Sitzber. Akad. Wien. 1844. 12:297; Am. Jour. Sci. Ser. 2. 1855. 19:362.

114 **Krantz, F.** Note on Crystals of Pyroxene from Orange County, N. Y. Pogg. Ann. Bd. 111:263.

115 **Kunz, G. F.** Apatite from near Yonkers, N. Y. Am. Jour. Sci. Ser. 3. 1888. 36:223.

116 ——— Fluorite from Macomb, N. Y. Am. Jour. Sci. Ser. 3. 1889. 38:72.

117 **Landis, E. K.** The Tilly Foster Mine (New York). Franklin Inst. Jour. 1900. 150:223.

118 **Lee, C. A.** Notice of the Ancram Lead Mine. Am. Jour. Sci. Ser. 1. 1824. 8:247.

119 **Leeds, A.** Augite from Amity, N. Y. Am. Jour. Sci. Ser. 3. 1873. 6:24.

120 ——— Notes on the Lithology of the Adirondacks. N. Y. State Cab. of Nat. Hist. 30th An. Rep't. 1878. p. 79.

121 **Luther, D. D.** The Economic Geology of Onondaga County. N. Y. State Mus. 49th An. Rep't. 1898. 2:241.

122 **Macfarland, J.** Discovery of Rock Salt at Wyoming in Western New York. Am. Jour. Sci. Ser. 3. 1878. 16:144.

123 **Martin, D. S.** Note on the Colored Clays recently exposed in Railroad Cuttings near Morrisania, N. Y. City. N. Y. Acad. Sci. Trans. 1890. 9:46.

124 **Mather, W. W.** Geol. N. Y. 4th Dist. 1846.

125 **Merrill, F. J. H.** Metamorphic Strata of Southeastern New York. Am. Jour. Sci. Ser. 3. 1890. 39:383.

126 ——— Note on the Colored Clays recently exposed in Railroad Cuttings near Morrisania, N. Y. City. N. Y. Acad. Sci. Trans. 1890. 9:45.

127 ——— Mineral Resources of New York State. N. Y. State Mus. Bul. 15. 1895.

128 ——— Geology of the Vicinity of Greater New York. N. Y. Acad. Sci. Trans. 1898. 21:72.

129 ——— Geology of the Crystalline Rocks of Southeastern New York. N. Y. State Mus. 50th An. Rep't. Apx. A. 1898. p. 21.

130 ——— Origin of the Serpentine in the Vicinity of New York. N. Y. State Mus. 50th An. Rep't. Apx. B. 1898. p. 32.

131 **Merrill, G. P.** Notes on the Serpentinous Rocks of Essex County, N. Y., from Aqueduct Shaft 26, N. Y. City, and from near Easton, Pa. U. S. Nat. Mus. Proc. 1890. 12:595.

132 ——— On the Ophiolite of Thurman, Warren County, N. Y., with remarks on the Eozoon canadense. Am. Jour. Sci. Ser. 3. 1889. 37:189.

133 **ses, A. J.** Mineralogical Notes; Pyrite Crystals from Kings Bridge, N. Y. Am. Jour. Sci. 3. 1893. 45:488.

134 **Nason, F. L.** Notes on some of the Iron-bearing Rock of the Adirondack Mountains. Am. Geol. 1893. 12:25.

135 ——— Some New York Minerals and their Localities. N. Y. State Mus. Bul. 4. 1888; Am. Jour. Sci. Ser. 3. 1889. 37:237.

136 **Nevius, J. N.** Fibrous Talc in St Lawrence County, N. Y. Eng. and Min. Jour. 1899. 47:234.

137 ——— Talc Industry of St Lawrence County, N. Y. N. Y. State Mus. 51st An. Rep't. 1899. 1:r121.

138 **Niven, W.** Xenotime, Monazite, etc., on Manhattan Island. Am. Jour. Sci. Ser. 3. 1895. 50:75.

139 **Penfield, S. L. & Forbes, E. H.** Hortonolite from Orange County, N. Y. Am. Jour. Sci. Ser. 4. 1896. 1:131.

140 ——— **& Ford, W. E.** Calcite Crystals from Union Springs, N. Y. Am. Jour. Sci. Ser. 4. 1900. 10:237.

141 ——— **& Howe, W. T. H.** On the Chemical Composition of Chondrodite, Humite and Clinohumite. Am. Jour. Sci. Ser. 3. 1894. 47:188.

142 ——— **& Sperry, E. S.** (Phlogopite) A very pure Magnesia Mica, Phlogopite, from Edwards, St Lawrence County, N. Y. Am. Jour. Sci. Ser. 3. 1888. 36:329.

143 **Pierce, James.** Discovery of Native Crystallized Carbonate of Magnesia on Staten Island with a Notice of the Geology and Mineralogy of the Island. Am. Jour. Sci. Ser. 1. 1818. 1:142.

144 ——— Carbonate of Magnesia, and very uncommon Amianthus, discovered near New York. Am. Jour. Sci. Ser. 1. 1819. 1:54.

145 ——— Account of the Geology, Mineralogy, Scenery, etc., of the Secondary Region of New York, New Jersey, and the Adjacent Regions. Am. Jour. Sci. Ser. 1. 1820. 2:181.

146 ——— Minerals of Lake Champlain. Am. Jour. Sci. Ser. 1. 1821. 4:113.

147 **Pierce, James**. On the Geology, Mineralogy, Scenery, etc., of the Highlands of New York and New Jersey. Am. Jour. Sci. Ser. 1. 1822. 5:26.

148 ——— Memoir on the Catskill Mountains with Notices of their Topography, Scenery, Mineralogy, Zoology, etc. Am. Jour. Sci. Ser. 1. 1823. 6:86.

149 **Putnam, B. T.** Notes on Samples of Iron Ore collected in New York. 10th Census U. S. 1886. 15:89–144.

150 **Rammelsberg, C. F.** Analysis of Pyroxene from Edenville, N. Y. Mineralchemie. 1875. p. 386.

151 **Vom Rath, G.** Diopside from DeKalb, N. Y. Sitzber, Niederrh, Ges. fur Nat. u. Heilk. 1886. p. 224.

152 ——— Pyroxene from Orange County, N. Y. Zeit. fur Kryst. u. Min. 1881. 5:495.

153 ——— Ueber Diopsid von DeKalb, N. Y. Zeit. fur Kryst. u. Min. 1888. 13:598.

154 ——— Alteration Products of Pyroxene from Orange County, N. Y. Pogg. Ann. Bd. 1860. 111:263.

155 ——— On Pyroxene from Diana, N. Y. Pogg. Ann. Bd. 1872. 144:377.

156 **Raymond, R. W.** Spathic Iron Ores of the Hudson River. Am. Inst. Min. Eng. Trans. 1876. 4:339.

157 ——— Pyrrhotite Deposits at Anthony's Nose, N. Y. Am. Inst. Min. Eng. Trans. 1894. 24:886.

158 **Ries, Heinrich.** List and Bibliography of Minerals occurring in Warwick Town, Orange County, N. Y. N. Y. Acad. Sci. Ann. 1894. 7:651.

159 ——— Monoclinic Pyroxenes of New York State. N. Y. Acad. Sci. Ann. 1896. 9:124.

160 ——— Geology of Orange County, N. Y. N. Y. State Mus. 49th An. Rep't. 1898. 2:393.

161 ——— Note on Beryl Crystal from N. Y. City. N. Y. Acad. Sci. Trans. 1898. 16:329.

162 ——— Allanite Crystals from Mineville, Essex County, N. Y. N. Y. Acad. Sci. Trans. 1898. 16:327.

163 ——— Clays of New York. N. Y. State Mus. Bul. 35. 1900.

164 ——— **& Eckel, E. C.** Lime and Cement Industries of New York. N. Y. State Mus. Bul. 44. 1901.

165 **Riggs, R. B.** Indicolite, so-called from Harlem, N. Y. Am. Jour. Sci. Ser. 3. 1887. 34:406.

166 **Robinson, S.** List of American Mineral Localities. Bost. 1826.

167 **Rogers, W. B.** On the Clinton Group and its Iron Ores. Bost. Soc. Nat. Hist. Proc. 1858. 6:340.

168 **Root, O.** On a Locality of Carbonate of Strontian. Am. Jour. Sci. Ser. 2. 1852. 13:264.

169 **Root, E. W.** On Wilsonite from St Lawrence County, N. Y. Am. Jour. Sci. Ser. 2. 1868. 45:47.

170 **Ruttman, F. S.** Notes on the Geology of the Tilly Foster Mine. Am. Inst. Min. Eng. Trans. 1887. 15:79.

171 **Sahlin, A.** Talc Industry of the Gouverneur District, St Lawrence County, N. Y. Am. Inst. Min. Eng. Trans. 1891. 21:583.

172 **Schmidt, A.** Die Talklagerstatten von St Lawrence County im Staat New York. Zeit. fur prak. Geol. 1897. 1:29.

173 ——— Die Magnetit-Lagerstatten bei Port Henry im Staat New York. Zeit. fur prak. Geol. 1897. 9:318.

174 **Schneider, Philip F.** The Limestones of Central New York. Stone. 1898. 18:26.

175 **Seybert, H.** Note on Green Pyroxene from Willsboro on Lake Champlain. Am. Jour. Sci. Ser. 1. 1822. 5:116.

176 **Shepard, C. U.** Sketch of the Mineralogy and Geology of the Counties of Orange, N. Y., and Sussex, N. J. Am. Jour. Sci. Ser. 1. 1832. 21:321.

177 ——— On the Strontianite of Schoharie, N. Y. Am. Jour. Sci. Ser. 1. 1835. 27:363.

178 ——— Notice of Warwickite, a new Mineral Species. Am. Jour. Sci. Ser. 1. 1838. 34:313, analysis; *Ibid.* Ser. 1. 1839. 36:85.

179 ——— On a supposed New Mineral Species. Am. Jour. Sci. Ser. 1. 1840. 39:357.

180 ——— 1 Dysyntribite, 4 Houghite } Mineralogical Notices. Am. Jour. Sci. Ser. 2. 1851. 12:209.

181 ——— Two new Minerals from Monroe, Orange County, N. Y. Am. Jour. Sci. Ser. 2. 1852. 13:392.

182 ——— Notice of the Meteoric Iron found near Seneca River, Cayuga County, N. Y. Am. Jour. Sci. Ser. 2. 1853. 15:363.

183 **Silliman, B.** Quartz from West Canada Creek. Am. Jour. Sci. Ser. 1. 1819. 1:241.

184 ——— Fluor Spar on the Genesee River. Am. Jour. Sci. Ser 1. 1821. 3:235.

185 ——— Notices of Minerals and Rocks chiefly in Berkshire, Mass., and Contiguous to the Waters of the Upper Hudson and Lakes George and Champlain. Am. Jour. Sci. Ser. 1. 1822. 4:40.

186 ——— Fibrous Gypsum of Onondaga County, N. Y Am. Jour. Sci. Ser. 1. 1829. 16:377

187 ——— Notice of a Mass of Meteoric Iron found at Cambria, near Lockport, N. Y. Am. Jour. Sci. Ser. 1. 1845. 48:388.

188 **Silliman, B jr.** On Monrolite. Am. Jour. Sci. Ser. 2. 1849. 8:385.

189 ——— Optical Examination of several American Micas. Am. Jour. Sci. Ser. 2. 1850. 10:372.

190 **Smith, J. L.** Warwickite. Am. Jour. Sci. Ser. 3. 1874. 8:432.

191 ——— **& Brush, G. J.** Note on the Composition of Hudsonite. Am. Jour. Sci. Ser. 2. 1853. 16:369; Am. Jour. Sci. Ser. 2. 1855. 19:362.

192 **Smith, Stephen.** Notice of the Salt Springs and Manufacture of Salt at Salina, Syracuse, etc., N. Y. Am. Jour. Sci. Ser. 1. 1829. 15:6.

193 **Smock, J. C.** Geological Reconnaissance in the Crystalline Rock Region, Dutchess, Putnam and Westchester Counties, N. Y. N. Y. State Mus. 39th An. Rep't. 1886. p. 166.

194 ——— Iron Mines and Iron Ore Districts in the State of New York. N. Y. State Mus. Bul. 7 1889.

195 **Smyth, C. H. jr.** A Third Occurrence of Peridotite in Central New York. Am. Jour. Sci. Ser. 3. 1892. 43:322.

196 ——— On the Clinton Iron Ore. Am. Jour. Sci. Ser. 3. 1892. 43:487.

197 ——— Alnoite containing an Uncommon Variety of Melilite. Am. Jour. Sci. Ser. 3. 1893. 46:104.

198 ——— Report on a Preliminary Examination of the General and Economic Geology of four Townships in St Lawrence and Jefferson Counties, N. Y. N. Y. State Mus. 47th An. Rep't. 1894. p. 687.

199 ——— Crystalline Limestones of the Adirondacks. Geol. Soc. Am. Bul. 1895. 6:263

200 ——— Fibrous Talc and Soapstone. Min. Ind. 1895. p. 37.

201 ——— Genetic Relations of Certain Minerals of Northern New York. N. Y. Acad. Sci. Trans. 1896. 15:260.

202 ——— Genesis of the Talc Deposits of St Lawrence County, N. Y. Sch. of Mines Quar. 1896. 17:333.

203 ——— Talc of St Lawrence County, N. Y. Am. Jour. Sci. Ser. 4. 1897. 3:76.

204 ——— Pseudomorphs from Northern New York. Am. Jour. Sci. Ser. 4. 1897. 4:309.

205 ——— Report on the Talc Industry of St Lawrence County, N. Y. N. Y. State Mus. 49th An. Rep't. 1898. p. 661.

206 ——— Report on the Crystalline Rocks of St Lawrence County. N. Y. State Mus. 49th An. Rep't. 1898. p. 477.

207 ——— Geology of the Adirondacks Region. Appalachia. 1899. 9:44.

208 ——— Report on Crystalline Rocks of Western Adirondacks. N. Y. State Mus. 51st An. Rep't. 1899. 2:471.

209 ——— Petrography of the Gneisses of the Town of Gouverneur, N. Y. N. Y. Acad. Sci. Trans. 12:203.

210 **Steel, J. H.** New Locality of Chrysoberyl. Am. Jour. Sci. Ser. 1. 1822. 4:37.

211 **Teschemacher, J. E.** Singular Crystals of Lead from Rossie, N. Y. Am. Jour. Sci. Ser. 1. 1844. 47:417.

212 **Thomson, T.** Chemical Examination of some Minerals, chiefly from America. N. Y. Acad. Sci. Ann. 1827. 3:9.

213 ——— Chemical Examination of American Minerals. N. Y. Lyceum Nat. Hist. Ann. 1827. 3:54.

214 ——— Analysis of the supposed Anthophyllite of New York. Am. Jour. Sci. Ser. 1. 1831. 19:359.

215 **Troost, G.** The Pyroxenes of the United States. Phil. Acad. Sci. Four. 1825. 3:105.

216 **Van Rensselaer, J.** Serpentine, etc., on New York Island. Am. Jour. Sci. Ser. 1. 1828. 14:192.

217 **Vanuxem, Lardner.** Note on Hudsonite. Phil. Acad. Sci. Jour. 3:68.

218 **Wendt, A. F.** The Iron Mines of Putnam County, N.Y. Am. Inst. Min. Eng. Trans. 1885. 13:478.

219 **Whitfield, J. E.** Danburite from Russell, St Lawrence County, N. Y. Am. Jour. Sci. Ser. 3. 1887. 34:285.

220 **Weidman, S.** Amphibole (Hudsonite) previously called a Pyroxene. Am. Jour. Sci. Ser. 4. 1903. 15:227.

221 **Williams, E. H.** On Crystals of Tourmaline with enveloped Orthoclase from Crown Point, N. Y. Am. Jour. Sci. Ser. 3. 1876. 11:273.

222 **Williams, G. H.** Paramorphosis of Pyroxene to Hornblende in Rocks. Am. Jour. Sci. Ser. 3. 1884. 28:259.

223 ——— Cause of the Apparently perfect Cleavage in American Sphene (Titanite). Am. Jour. Sci. Ser. 3. 1885. 29:486.

224 ——— The Gabbros and Diorites of the Cortlandt Series near Peekskill, N. Y. Am. Jour. Sci. Ser. 3. 1886. 31:26.

225 ——— On the Serpentine (Peridotite) occurring in the Onondaga Salt Group at Syracuse, N. Y. Am. Jour. Sci. Ser. 3. 1887. 34:137

226 ——— Rutil nach Ilmenit in veränderten Diabase Pleonast (Hercynit) in Norit von Hudson-Fluss. Perowskit in Serpentin (Peridotit) von Syracuse, N. Y. Neues Jahrbuch. 1887. 2:263.

227 ——— On some Remarkable Crystals of Pyroxene from Orange County N. Y. Am. Jour. Sci. Ser. 3. 1887. 34:275

228 ——— Contact Phenomena of the Cortlandt Series near Peekskill, N. Y. Am. Jour. Sci. Ser. 3. 1888. 36:254.

229 ——— On the possibility of Hemihedrism in the Monoclinic Crystal System; with especial Reference to the Hemihedrism of Pyroxene. Am Jour. Sci. Ser. 3. 1889. 38:115.

230 ——— Amphibole, St Lawrence County, N. Y. Am. Jour. Sci. Ser. 3. 1890. 39:352.

231 **Williams, S. G.** Geological Relations of the Gypsum Deposits in Cayuga County, N. Y. Am. Jour. Sci. Ser. 3. 1885. 30:212.

Other authorities

a American Museum of Natural History
b Brooklyn Institute, mineral collection
c Columbia University, Egleston Mineralogical Museum
d Hamilton College Museum
e New York State Museum
f Union College Museum
g Mr E. C. Eckel
h Mr Gilbert van Ingen
j Mr W. W. Jefferies
k Prof. J. F. Kemp
l Mr H. O. Clough
m Dr F. J. H. Merrill
p Mr H. S. Peck
w The author

ALBANY

NO.	LOCALITY	SPECIES	DESCRIPTION
	Bethlehem		
1	Kenwood, north bank Normans kill . .	calcite.........	small nail head crystals..........
		quartz.........	small crystals ....
		pyrite.........	nodular concretions and crystals..
2	1½m. n. w. Coeyman................	epsomite.......	efflorescence on limestone ....
		calcite.........	stalactites and sinter............
		gypsum........	massive and snowy ....
3	Crystal hill, Glenmont	quartz.........	crystals ....
	Coeyman		
4	Coeyman.........................	gypsum........	selenite crystals...............
	New Scotland		
5	Indian Ladder.....................	calcite.........	crystals ....
		pyrite.........	small crystals ....
6	1m. e. Indian Ladder	calcite.........	small brilliant crystals ....
		dolomite.......	white and pinkish aggregates.....
		aragonite......	radiating needles ....
7	½m. s. of New Salem................	pyrite.........	small bright crystals............
	Watervliet		
8	Campbell........................	quartz.........	yellow drusy crystals ....

ALLEGANY

The Devonian shales and sandstones have been successfully drilled for petroleum in many in mineral localities.

BROOME

The Devonian shales, sandstones and conglomerates of this county do not include mineral

CATTARAUGUS

The Devonian shales and sandstones which constitute the rocks of this county have been otherwise these formations are unprolific in mineral localities.

CAYUGA

	Auburn		
9	at base of hill on e. bank Owasco creek	celestite.......	thin radial blades ....
		calcite.........	in minute crystals and rounded masses.....................
		fluorite........	....
		epsomite	....
	Springport		
10	Thompson's plaster beds............	sulfur.........	semicrystalline ....
		gypsum	selenite.......................

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
1	....	vein in shale	quartz....................	*w*
	....	"	calcite..................	*w*
	....	in shale........................	....	*w*
2	......	on limestone......................	....	5, 43
	....	in shale........................	gypsum.............	5, 43
	....	"	calcite..................	5, 43
3	....	"	....	5, 43
4	....	in clay........................	....	5, 43
5	....	in limestone......................	....	*l*
	....	"	....	*l*
6	....	"	dolomite, aragonite.........	*l*
	....	"	calcite..................	*l*
	....	"	"	*l*
7	....	in shale........................	....	*w*
8	....	"	....	5, 43

COUNTY

localities in the southern section of the county, otherwise these formations are not prolific

COUNTY

localities of sufficient importance to note in this list.

COUNTY

successfully drilled for petroleum in many localities in the southern section of the county,

COUNTY

9	....	in dark Salina limestone	calcite, fluorite etc.........	5, 43
	....	in slate........................	celestite	5, 43
	....	in Salina limestone..................	" calcite............	5, 43
	....	"	calcite, fluorite	5, 43
10	xx	in gypsum of Salina..................	....	5, 43
	x.......	"	sulfur	43

CAYUGA

NO.	LOCALITY	SPECIES	DESCRIPTION
	Union Springs		
11	....	gypsum	selenite......................
		calcite.........	modified and twin crystals.......
		dolomite.......	curved crystals.................
		quartz.........	crystals ....

CHAUTAUQUA

The Devonian shales and sandstones which constitute the rocks of this county do not include

CHEMUNG

See Chautauqua

CHENANGO

See Chautauqua

CLINTON

	Ausable		
12	Arnold hill mines $1\frac{1}{2}$m. w. Ferrona	magnetite	medium fine crystalline..........
		fluorite........	purple and green................
		pyrite	....
		quartz	red jasper ....
13	Cook mine $1\frac{1}{2}$m. e. Ferrona..........	magnetite	medium fine crystalline ....
		calcite.........	sharp needle crystals, radiating ..
		amphibole.....	crystals, dark green to black.....
		"	black fibrous hornblende.........
		oligoclase.....	in broadly striated cleavages.....
14	Winter mine $4\frac{1}{2}$m. e. Ferrona.........	magnetite	....
	Black Brook		
15	Palmer hill mines $1\frac{1}{2}$m. n. Ausable Forks	magnetite	coarse grained..................
		orthoclase	flesh-colored ....
16	Tremblay's mine $1\frac{1}{2}$m. w. Clayburg....	magnetite	....
17	Bowen & Signor's mine, Williamsb'g ..	"	....
	Chazy		
18	Chazy..........................	calcite.........	small nail head crystals..........
	Dannemora		
19	Dannemora......................	magnetite	....
20	Chateaugay mines Lyon Mountain....	"	coarse crystalline ore...........
		apatite........	rounded grains ....
21	Lyon Mountain near Roger's field.....	pyroxene......	long, well formed crystals with granular core.................

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
11	x	in Onondaga limestone	calcite, dolomite	43
	xx	"	dolomite	140
	xx	"	calcite	140
		"	"	140

COUNTY

mineral localities of sufficient importance to note in this list.

COUNTY

county.

COUNTY

county

COUNTY

12	x *	veins in gneiss	quartz, feldspars	149, 194
	x	"	" calcite	43
		"	"	*e*
		vein in gneiss	magnetite	*e*
13	*	veins in gneiss		*e*
		"		*e*
	x	"	magnetite, feldspar	*e*
		in gneiss	feldspar	*e*
	x	"	amphibole (hornblende)	*e*
14	* †	"		194
15	*	"	orthoclase	149, 194
		"	magnetite, quartz	149
16	* †			149, 194
17	*			149
18		fault plane in limestone		*h*
19	*			194
20	*	in granite	apatite, quartz etc	194
		" magnetite		*m*
21		" Bostonite dikes	plagioclase, olivin	159

COLUMBIA

NO.	LOCALITY	SPECIES	DESCRIPTION
	Ancram		
22	Ancram lead mines	galena	foliated and granular
		sphalerite	yellow and brown colors
		chalcopyrite	large masses with blue tarnish
		wulfenite	
		serpentine	
23	½ m. s.e. Ancram lead mines	albite	small transparent crystals
24	Morgan iron mine 2m. n. Ancram lead mines	limonite	loose decomposed ore cut by concretionary siderite
		siderite	
25	Reynolds mine ½m. e. Halstead	limonite	
		siderite	
	Austerlitz		
26		chalcocite	massive
	Canaan		
27		chalcopyrite	
		chalcocite	massive
	Copake		
28	Copake N. Y. & H. R. R.	limonite	large ore beds
		graphite	
	Hillsdale		
29	group of 3 mines, 3m. e. Hillsdale, 3m. n.e. Hillsdale, 1½ m.e.N. Hillsdale	limonite	
	Greenport		
30	near Hudson	gypsum	selenite
		wad	
		siderite	loose, decomposed material
		dolomite	grading into ankerite
		epsomite	efflorescences on slate
		calcite	small prismatic crystals
	Livingston		
31	Burden mines 2 m. s.e. Linlithgo	siderite	massive material altering to limonite
		quartz	small crystals
	Stuyvesant		
32	s. of Cary Brick Co., Coxsackie	gypsum	selenite crystals

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
22	*†	vein in talcose slate..................	sphalerite, chalcopyrite	5, 43
	*†......	"	galena....................	5, 43
	*†......	"	sphalerite, galena..........	5, 43
	....	"	....	5, 43
	......	"	....	*w*
23	x.......	in quartz vein......................	quartz....................	*w*
24	*† ...	" slate............................	....	149, 194
	*†	"	....	149, 194
25	*†......	....	....	149, 194
		....	....	149, 194
26	....	in quartz vein traversing limestone.....	....	5
27	....	in veins of galena.....................	....	43
	....	"	....	5, 43
28	*.	in slaty rock and limestone...........	....	43, 149, 194
	....	"	....	43
29	*†	in crystalline limestone...............	....	194
30	xx......	....	....	43
	x.......	....	....	43
	x.......	....	....	43
	....	....	....	43
	....	....	....	5
	....	in Helderberg limestone.....	....	*w*
31	*†......	in shale.............................	quartz....................	194
	....	seams and pockets in iron ore..........	siderite..................	*w*
32	x.......	in clay bank.......................	....	*w*

CORTLAND

The Devonian rocks of this county do not include mineral

DELAWARE

See Cortland

DUTCHESS

NO.	LOCALITY	SPECIES	DESCRIPTION
	Amenia		
33	Manhattan mine, Sharon Station / Amenia mine, Amenia......... }	limonite......	....
		turgite........	....
		siderite.......	....
		chalcopyrite...	....
	Beekman		
33a	Sylvan Lake mines, near Sylvan Lake	limonite......	....
	Dover		
34	Dover Plains marble quarry..........	dolomite......	massive.......................
		amphibole....	tremolite.....................
35	Deuel Hollow mine 2m. s.e. South Dover	limonite......	....
36	Dover mine, Dover Furnace station...	"	....
		staurolite.....	small crystals..................
		garnet........	small red and brown crystals.....
	East Fishkill		
37	Pecksville.........................	graphite......	foliated and granular............
		talc..........	gray and white of uneven structure
		amphibole	pale green actinolite and hydrous anthrophyllite................
		pyroxene	augite........................
38	Fishkill iron mines East Fishkill......	limonite......	....
	Northeast		
39	near Smithfield....................	chalcocite.....	....
		chalcopyrite...	....
		galena........	....
		sphalerite.....	....
40	Riga Mine, Mount Riga.............	limonite......	....
40a	Malby mine, 1½ m. n.e. Millerton	"	....

COUNTY

localities of sufficient importance to note in this list.

COUNTY

county.

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
33	x*†	in grayish blue limestone	siderite etc	149, 194
	x*†	"	limonite	43
	x*†	"	"	43
		"	"	5
33a	*†			149, 194
34		in crystalline limestone		5, 43
		"	dolomite	5, 43
35	x*†	"		149, 194
36		between strata of mica schist		149, 194
		in mica schist	garnet	5, 43
	x	"	staurolite	5, 43
37		in vein of granite		3
				5, 43
	x	in talc and limestone		5, 43
		" limestone	amphibole, dolomite	43
38	x*†	" schist		149, 194
39				5, 43
				43
				43
				43
40	*†	in limestone		149, 194
40a	*†	"		149, 194

DUTCHESS

NO.	LOCALITY	SPECIES	DESCRIPTION
	Pawling		
41	Pawling mine 2½m. w.n.w. of Pawling.	limonite.......	....
	Poughkeepsie		
42	s. end of r.r. cut at Mine Point.......	anthracite.....	....
	Unionvale		
43	Clove mine........................	limonite.......	....
		gibbsite.......	....

ERIE

The Devonian rocks in the vicinity of

ESSEX

	Chesterfield		
44	s.w. corner of town.................	magnetite......	titaniferous....................
	Crown Point		
45	iron mines, Hammondsville.........	magnetite.....	medium fine crystalline..........
		pyroxene......	small black crystals.............
46	1 m. s. Hammondsville.............	apatite........	elongated terminated prisms......
		apatite........	mamillary eupyrchroite..........
		tourmalin......	fine brown crystals.............
		chlorite........	....
		quartz..........	crystals........................
		calcite.........	....
		pyrite..........	crystals........................
		garnet.........	brown crystals.................
		wernerite......	....
		oligoclase......	aventurin.....................
		zircon.........	crystals........................
		chalcopyrite....	....
		epidote........	small imperfect crystals ....
47	Skiff mine 2 m. s. Hammondsville...	magnetite......	....
	Elizabethtown		
48	Gates mine 1m. s.e. New Russia.......	"	titaniferous ....
	Keene		
49	Weston mine 1m. s.w. Keene.........	"	....
50	2m. s.e. Keene.....................	pyroxene......	black crystals..................
51	Mount Marcy.........................	"	dillage in foliated masses........

See also locality 65.

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
41	*†....	in limestone........................	....	149, 194
42	*†......	in green shale....................	quartz....................	*h*
43	*.......	....	....	43
	....	....	....	43

COUNTY

Buffalo furnish considerable natural gas.

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
44	*†......	in norite........................	....	194
45	*.......	in gneiss........................	quartz, plagioclase.........	149, 194
	....	"	magnetite................	159
46	x........	in limestone....................	calcite....................	5, 43
	x*†....	"	quartz....................	5, 43, 91
	xx.....	"	apatite, orthoclase.........	43
	....	"	....	43
	....	"	....	43
	....	"	....	43
	x......	"	....	5, 43
	x.......	in gneiss, at contact...............	....	43
	x.......	"	orthoclase, magnetite	43
	....	"	quartz, "	5, 43
	....	"	....	43
	....	"	quartz....................	43
	....	....	" oligoclase...........	43
47	....	....	....	194
48	*†......	in gabbro........................	....	149, 194
49	*†......	in crystalline limestone...............	calcite, epidote............	149, 194
50	....	"	wernerite................	159
51	....	in gabbro........................	....	159

ESSEX

NO.	LOCALITY	SPECIES	DESCRIPTION
	Lewis		
52	Lewis Corners....................	wollastonite....	abundant....................
		labradorite.....	dark gray, brilliant play of colors..
		amphibole.....	actinolite, hornblende...... . ...
		arsenopyrite....	massive....................
53	Cross..........................	wollastonite....	abundant....................
		garnet.........	colophonite..................
	Minerva		
54	Minerva mine....................	magnetite......	....
	Moriah		
55	Sanford ore bed 6m. w. Port Henry....	"	....
		apatite........	green and brown crystals.........
		allanite........	large crystals..................
		lanthanite......	in delicate scales. ....
		amphibole.....	actinolite and hornblende........
56	Mineville, Hall ore bed.............	magnetite......	medium fine grained............
		zircon.........	cinnamon red..................
57	Mineville, mine 21 etc..............	magnetite......	in beautifully developed crystals ..
		zircon.........	large crystals..................
58	6m. n.w. P't H'n'y (Roe's spar bed)..	tourmalin......	in prisms sometimes altered internally
		muscovite......	....
		quartz.........	rose quartz..................
	Tredway quarry..................	serpentine......	verd antique marble............
59	Port Henry (Pease quarry etc.).......	pyroxene......	jet black massive and crystals.....
		"	white & pink diopsid in crystals....
		pyrite.........	crystals.....................
		pyrrhotite......	strongly magnetic..............
		graphite.......	massive......................
		amphibole.....	hornblende..................
		wollastonite....	crystalline..................
		orthoclase	adularia sometimes in minute transparent crystals ....
		titanite........	yellowish brown...............
		tourmalin......	brown......................

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
52	....	in gabbro	garnet, quartz etc..........	5, 43
	x.......	"	....	5
	....	"	....	5, 43
	....	"	hornblende................	5, 43
53	....	"	amphibole, garnet..........	5, 43
	....	"	....	5, 43
54	*†......	....	....	194
55	*†......	in gneiss........................	apatite, amphibole..........	5, 43, 149, 175, 194
	....	"	....	5, 43
	xx......	"	magnetite, apatite	12, 39, 162
	....	in fissures in the ore and on allanite.....	magnetite, allanite	12, 43
		....	magnetite, allanite..........	5, 43
56	x*......	in gneiss........................	zircon....................	43, 194
	x.......	" quartz vein.....................	magnetite.................	5, 43
57	xx*.....	" gneiss........................	apatite....................	43, 194
	x.......	" quartz........................	magnetite.................	43
58	x.......	" granular limestone...............	....	5, 43, 98, 221
	....	"	....	5
	x.......	"	....	5, 43, 98
	x.......	"	....	5, 43, 131
59	x.......	"	magnetite.................	5, 159
	x.......	"	titanite, amphibole etc......	5, 159
	x.......	"	pyrrhotite................	5, 43
	....	"	pyrite....................	5, 43
	....	"	tourmalin, pyroxene........	43
	....	"	oligoclase, quartz..........	98
	....	"	pyroxene, albite...........	5, 43
	x.......	"	pyroxene, titanite etc.......	5, 43
	x.......	"	amphibole................	98
	xx. ...	"	" titanite..........	98

ESSEX

NO.	LOCALITY	SPECIES	DESCRIPTION
	Moriah (*continued*)		
60	Mill brook 2m. n.w. of Port Henry.....	calcite.........	crystals........................
		quartz.........	smoky........................
		pyroxene......	....
		graphite.......	small hexagonal crystals.........
61	Cheever mine 2m. n. Port Henry.......	magnetite......	fine crystalline ore..............
		albite.........	greenish.......................
		pyroxene......	augite........................
	Newcomb		
62	Adirondack mines near Lake Sanford..	magnetite	fine grained titaniferous ....
		labradorite....	deeply striated..................
		hypersthene....	....
63	south shore Lake Harris 1m. e. of Newcomb	tourmalin	brown and green...............
		titanite........	twinned crystals................
		zircon.........	greenish black..................
		muscovite	yellowish green.................
		wernerite......	semitransparent................
		albite	opalescent mainly in druses ......
64	McIntyre 2m. s.e. Lake Sanford	labradorite....	....
		garnet.........	....
		magnetite	....
	North Elba		
65	*a*Cascadeville, 6m. s.e. Lake Placid ...	pyroxene......	light green rounded grains ....
	Schroon		
66	Paradox Lake mines................	magnetite	....
		calcite.........	fine green translucent masses.....
		pyroxene......	....
		chondrodite ...	....
		tourmalin......	crystals ....
		wernerite......	....
	Ticonderoga		
67	Chilson lake (Paragon lake)........	apatite..	....
		garnet.........	....
		pyroxene......	crystals and coccolite...........
		vesuvianite	....
		wernerite......	....
		magnetite	....
		calcite.........	blue ....

a This locality extends into Keene.

COUNTY (*continued*)

NO	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
60	x	in white limestone	pyroxene, amphibole, albite	5, 43, 98
	x	"	calcite	*e*
		"	" amphibole etc	43
		"	"	98
61	x*	Grenville schist		149, 194
		"	magnetite	5
		"	" labradorite	159
62	*†	in gabbro	labradorite, hypersthene	149, 194
		"	hypersthene	43
		"	labradorite	43
63	xx	in Grenville limestone	apatite, zircon etc	135
	x	"	"	135
	x	"	tourmalin, apatite	135
		"		135
		"		135
		"		135
64	x	in gabbro	magnetite	43
		"		43
	x	"	labradorite	43
65		in calcite vein		159
66	*†	in Grenville limestone	proxene, chondrodite	194
	x	"	"	5,43
		"	wernerite, calcite	43
	x	"	tourmalin, wernerite	43
		"	chondrodite etc	43
		"	pyroxene, calcite	5
67		contact gneiss and limestone		43
	x	"		43
	x	"		5,43
		"		5,43
	x	"	pyroxene, calcite	43
		"		43
		"		43

ESSEX

NO.	LOCALITY	SPECIES	DESCRIPTION
	Ticonderoga (*continued*)		
68	Kirby graphite mine 3m. n.w. Ticon'ga	graphite	crystals and folia
		pyroxene	large dark green crystals carrying inclusions of calcite
		wernerite	perfect crystals
		titanite	yellowish gray crystals
		tourmalin	black
		apatite	
		calcite	light yellow
		quartz	
69	Mount Defiance	pyroxene	salite
		magnetite	
		cacoxenite	
70	Rogers Rock	graphite	
		wollastonite	
		garnet	crystallized and massive colophonite
		orthoclase	brown, red and yellow adularia
		pyroxene	massive and granular coccolite
		titanite	abundant small, brown crystals
		calcite	masses of minute crystals
	Westport		
71	Splitrock mine 5m. n.e. Westport	magnetite	fine grain titaniferous
		graphite	
		labradorite	
		prehnite	chiltonite
	Willsboro		
72		wollastonite	
		garnet	colophonite
		pyroxene	green coccolite
		amphibole	hornblende in interesting forms
		quartz	milky

FRANKLIN

The rocks of this county afford no recorded mineral localities of sufficient importance

FULTON

The rocks of this county afford no recorded mineral localities of sufficient importance

GENESEE

Salt is mined and obtained in solution from the rocks of the Salina by drilling

COUNTY *(continued)*

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
68	xx*.....	in crystalline limestone and mica schist	calcite	43, 135
	xx......	"	graphite wernerite	5, 43,135
	x	contact limestone and gneiss..........	" pyroxene etc	5. 43, 135
	....	in white granular and lamellar feldspar.	pyroxene, wernerite........	5, 43, 135
	....	"	wernerite, pyroxene........	5, 43, 135
	....	....	"	135
	....	vein mineral......................	....	135
		"	....	135
69	....	....	....	5
	....	....	....	194
	....	....	....	5, 43
70	x	in crystalline limestone	pyroxene titanite..........	43
	x	"	garnet, orthoclase..........	5, 43
	x	"	....	5, 43
	....	"	....	5, 43
	x	"	orthoclase, titanite	5, 43
	....	"	....	5, 43
	....	"	....	5
71	*†......	in norite	....	149, 194
	....	"	....	*m*
	....	"	....	5, 43
	....	"	....	43
72	x	in vein traversing gabbro	garnet....................	5, 43
	x	"	wollastonite, pyroxene......	5
	x	"	" titanite, garnet...	5, 43, 175
	....	"	black tourmalin	5, 43
	....	"	....	*e*

COUNTY

to note in this list though minor localities undoubtedly occur in the crystalline rocks.

COUNTY

to note in this list though minor localities undoubtedly occur in the crystalline rocks.

COUNTY

through the Devonian rocks which cover the southern section of this county.

GREENE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Catskill		
73	Diamond hill, Catskill	quartz	fine large crystals
74	Austin's glen 2m. n.w. Catskill	calcite	massive and coarsely crystallized
		quartz	small crystals
	New Baltimore		
75	limestone quarry at New Baltimore	calcite	interesting crystals
		quartz	crystals in parallel position

HAMILTON

The rocks of this county afford no recorded mineral localities of sufficient importance to note

HERKIMER

NO.	LOCALITY	SPECIES	DESCRIPTION
	Fairfield		
76	Diamond hill 3m. n.e. Fairfield	quartz	crystals
		barite	massive yellowish white
	Little Falls		
77	Little Falls	quartz	brilliant transparent crystals
		barite	yellowish white lamellar masses
		dolomite	white and pearly crystals
78	1m.s. L. Falls in bed of small stream	calcite	white crystals
		ankerite } siderite }	included under brown spar
		orthoclase	flesh colored cleavages
	Newport		
79	Middleville	quartz	detached crystals and groupings
		calcite	flat crystals nail head type
		dolomite	white and pearly crystals
80	Newport	quartz	detached crystals
	Salisbury		
81	Salisbury	quartz	crystals larger than preceding
82	near Salisbury Center	sphalerite	
		galena	
		pyrite	
		chalcopyrite	
83		pyroxene	green coccolite
	Stark		
84	near Starkville	celestite	fibrous, bluish or blue
		gypsum	

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
73	x	embedded in stiff clay bet. layers of slate		5, 27, 43
74		veins in shale	quartz	*w*
		"	calcite	*w*
75	x	in Helderberg limestone		*p*
	xx	"		*e*

COUNTY

in this list though minor localities undoubtedly occur in the crystalline rocks.

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
76	x	in Beekmantown limestone	barite	5, 43
		"	quartz	5, 43
77	xx	in cavities in Beekmantown limestone	barite, calcite	5, 43
		" Beekmantown limestone	quartz dolomite	5, 43
		"	calcite quartz	5
78		Trenton limestone	siderite, orthoclase	5, 43
		"	calcite	43
		"		5
79	xx	in cavities in Beekmantown limestone	calcite, dolomite	5, 43
	x	" Beekmantown limestone	quartz "	5, 43
		" cavities in Beekmantown limestone		5, 43
80	x	"		5, 43
81	xx	"		5, 43
82		vein in gneiss		5, 43
		"		5, 43
		"		43
		"		5, 43
83		in Beekmantown limestone	calcite	5
84		in Salina waterlime	gypsum	5, 43
		"	celestite	43

JEFFERSON

NO.	LOCALITY	SPECIES	DESCRIPTION
	Adams		
85	near North Adams.................	fluorite........	pink and green................
		barite.........	....
	Alexandria		
86	High island, St Lawrence river........	tourmalin......	long prisms.....................
		amphibole.....	....
		orthoclase......	....
		celestite.......	....
87	Omar...........................	beryl..........	....
		hematite.......	....
	Antwerp		
88	Antwerp, Sterling mine.............	hematite.......	bright flat crystals and massive red
		stilpnomelane..	chalcodite in velvety brown masses
		siderite........	small crystals and crystal. masses.
		ankerite.......	"
		millerite.......	capillary crystals lining cavities...
		quartz.........	small transparent crystals........
		"	chalcedony....................
		sphalerite......	modified crystal (rare)...........
		serpentine......	red and green concentric bands....
89	aOxbow, west shore of Yellow lake ...	calcite.........	large crystals and cleavages.......
		barite.........	porous coralloid................
90	near Vrooman's lake...............	calcite.........	cleavage masses................
		fluorite........	green cubes....................
		pyrite.........	....
		chalcopyrite....	....
		vesuvianite.....	terminated crystals.............
		phlogopite	....
		pyroxene......	green crystals..................
		titanite........	....
91	2m. s.w. Oxbow....................	limonite.......	bog iron ore..................
		serpentine.....	yellowish green ....
92	....	orthoclase.....	....
		wernerite......	....
		tourmalin......	yellow (rare)..................

a *See also* St Lawrence county.

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
85	....	in limestone........................	barite....................	43, 77
	....	"	fluorite..................	43, 77
86	x.......	in gneiss..........................	amphibole, orthoclase.......	5, 43, 77
	....	"	tourmalin, orthoclase... ..	5, 43
	x.......	"	" etc...........	5, 43
	....	in limestone........................	....	43
87	x.......	" gneiss..........................	feldspar..................	43
	....	"	....	43
88	x*......	in gneiss..........................	siderite, quartz etc..........	5, 43
	xx	"	calcite, hematite...........	20, 43
	x.......	"	hematite..................	43
	x.......	"	"	43
	xx	"	"	43, 78
	....	"	" siderite etc.......	43
	x.......	"	" "	*c*
	x.......	"	"	*w*
	....	"	"	*w*
89	xx	in limestone........................	....	5, 43
	....	"	calcite....................	43
90	xx	vein in limestone...................	fluorite..................	43
	x.......	"	calcite....................	43
	....	"	....	43, 77
	....	"	....	43, 77
	....	"	pyroxene, titanite..........	43, 77
	xx	in gneiss..........................	"	43
	x.......	"	titanite, phlogopite.........	5, 43
	....	"	pyroxene.................	43, 77
91	x.......	"	orthoclase................	43
	x.......	in vein of crystalline limestone........	....	5, 43
92	x.......	" gneiss..........................	wernerite................	43
	....	"	orthoclase, titanite.........	43
	....	"	....	43

JEFFERSON

NO.	LOCALITY	SPECIES	DESCRIPTION
	Brownville		
93	Brownville, banks of Black river......	celestite.......	slender crystals ....
		calcite........	....
94	Pillar Point, Lee farm on n. shore.....	barite.........	massive banded structure ....
	Clayton		
95	near Depauville.....................	celestite.......	....
	Lyme		
96	Chaumont, Chaumont bay...........	"	slender white radiating needles...
	Philadelphia		
97	Shirtliff mine, Philadelphia...........	hematite......	....
98	Indian river...........	garnet.........	....
	Theresa		
99	Theresa.........................	fluorite.......	....
		calcite........	....
		hematite......	....
		amphibole.....	....
		serpentine	....
		celestite.....	white crystalline masses.........
		strontianite....	" ....
100	s.e. bank of Muscalonge lake.....	fluorite........	sea-green cubes................
		phlogopite.....	....
		chalcopyrite....	....
		apatite........	....
	Watertown		
101	banks of Black river................	amphibole.....	white tremolite also brown & gray.
	Wilna		
102	Natural Bridge.....................	muscovite (gieseckite)	in six sided prisms pseudomorphs after nephelite...............
		talc (steatite)..	pseudomorphs after apatite pyroxene, orthoclase etc............
103	1m. n. Natural Bridge...............	calcite........	modified white crystals.. ....
	2m. e. Natural Bridge, *see* Lewis co.		

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
93	....	Trenton limestone	calcite	5, 43, *w*
	....	"	celestite	43, *w*
94	*†	"	calcite	5, 43, 77, *w*
95	....	"		5
96	....	"		5, 43
97	*†	in gneiss		194
98	x	"		43
99	x	gneiss limestone contact	calcite, quartz	43
	x	"	fluorite	43
	....	"	serpentine	43
	....	"		43
	....	"	hematite	43
	....	"	calcite fluorite	43, 77
	....	"	"	43
100	xx	in limestone gneiss contact	calcite, apatite	5, 43
	x	"	"	43
	....	"		5, 43
	....	"		43
101	....	in Grenville limestone	calcite	5, 43
102	xx	in decomposed Grenville limestone		43
	.....	"		43
103	....	in Grenville limestone		5, 43

LEWIS

NO.	LOCALITY	SPECIES	DESCRIPTION
	Diana		
104	2m. e. Natural Bridge (Ashmore's f'rm)	apatite........	large green crystals ....
		wernerite......	white, bluish and dark gray crystals
		pyroxene	dark green to black crystals augite
		amphibole.....	tremolite ....
		talc...........	rensselaerite..................
		wollastonite....	abundant white crystals ....
		serpentine......	variegated.....................
		titanite........	dark brown crystals............
		zircon.........	rare...........................
		quartz.........	doubly terminated crystals.......
		calcite.........	blue...........................
		graphite.......	....
		orthoclase......	modified crystals...............
		hematite	....
105	Harrisville, 2m. e. Bonaparte lake.....	wollastonite....	large crystals..................
	Greig		
106	Greig	magnetite......	....
		pyrite	....
	Martinsburg		
107	vicinity of Martinsburg, ¾m. n.w. of Martinsburg....................	calcite.........	prismatic, terminated crystals....
		fluorite........	green, nearly transparent crystals.
		pyrite.........	....
		galena.........	modified cubes..................
		sphalerite......	granular, massive..............

LIVINGSTON

Salt and gypsum are obtained from the rocks of the Salina in a number of localities; sec-

MADISON

The rocks of this county afford no recorded mineral

MONROE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Rochester		
108	Pike's quarry......................	dolomite.......	in geodes.....................
		calcite.........	in geodes also stalactites.........
		gypsum........	selenite and snowy.............

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
104	xx	limestone syenite contact	calcite	5, 43
	xx	"	"	5
	xx	"	wernerite	5, 43, 155 159, j
	x	"	calcite	43
	x	"	" serpentine	43, 77
	xx	"	" pyroxene	5, 43, 77, j
		"	talc	43
	x	"	wernerite, pyroxene	5, 43, j
		"	"	5, 43, 77
	x	"		43
		"	wernerite, pyroxene	j
		"	"	43
		"	"	j
		"	"	43
105		in decomposed Grenville limestone		43, c
106		in gneiss		43, 77
		"		43, 77
107	x	in Trenton limestone	fluorite, galena etc	5, 43
		"	calcite, pyrite, galena	5, 43
		"	galena, sphalerite, fluorite	5, 43
		"	pyrite, sphalerite	5, 43
		"	" galena	5, 43

COUNTY

ondary celestite, barite and calcite are also found in septaria in Genesee shale at several places.

COUNTY

localities of sufficient importance to note in this list.

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
108	x	in Niagara limestone	calcite, celestite, gypsum	5, 43, h
		"	dolomite etc	43, h
		"	"	43

MONROE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Rochester (*continued*)		
	Pike's quarry (*continued*)	celestite	nodular
		fluorite	occasionally in cubes
		barite	massive snowy
		galena	
		sphalerite	honey-brown crystals
108a	Gorge of Genesee river	hematite	Clinton ore

MONTGOMERY

NO.	LOCALITY	SPECIES	DESCRIPTION
	Palatine		
109	2m. e. Spraker's Basin	quartz	singly terminated crystals and drusy masses
		"	chalcedony
		garnet	
		anthracite	
	Root		
110	on Flat Creek 1½m. s.e. Spraker's B's'n	sphalerite	minute transparent light yellow crystals
		barite	lamellar masses
		galena	
		pyrite	massive
		calcite	stalactitic
		dolomite	brown and pearly
111	near Spraker's Basin	rutile	minute crystals

NASSAU

The rocks of this county are deeply covered with drift and artificially

NEW YORK

NO.	LOCALITY	SPECIES	DESCRIPTION
112	Corlaer's hook, Canal st. and East river	hypersthene	
113	Kip's bay, 34th st. and East river	heulandite	
114	38th st. and East river	epidote	
		orthoclase	pinkish crystals
115	42d st. and 4th av	siderite	spheric aggregates
		dolomite	crystals
116	43d–44th st. and 1st–3d av	molybdenite	disseminated scales
		calcite	crystals crusted with pyrite
		beryl	small crystals
		tourmalin	black crystals
		muscovite	large brown crystals
		oligoclase	
		garnet	
117	W. 35th st	garnet	large crystal, 6 inches diameter

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
	....	in Niagara limestone...............	dolomite etc...............	5, 43
	....	"	"	5, 43
	....	"	....	43, *h*
	....	"	sphalerite..................	5, 43
	....	"	galena, calcite, gypsum.....	5, *h*
108a	*†......	"	....	*m*

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
109	....	in gneiss.........................	garnet....................	5, 43
	....	"	"	5, 43
	....	"	quartz....................	5, 43
	....	"	....	43
110		in Trenton limestone...............	galena, barite..............	5, 43
	....	"	" sphalerite, calcite.....	5, 43
	....	"	barite "	43
	....	"	" "	5, 43
	....	"	galena, sphalerite etc........	5, 43
	....	"	....	5
111	....	in Beekmantown limestone..........	....	5, 124

COUNTY

made land; deep excavations may however develop mineral localities.

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
112	....	granite boulder.....................	....	5, 28
113	....	on mica schist.....................	stilbite..................	43
114	....	granite vein......................	orthoclase, prochlorite......	5
	....	"	epidote...................	5, 43, *c*
115	....	....	dolomite..................	*e*
	....	....	siderite..................	*e*
116	....	in mica schist.....................	kalinite..................	61
	....	"	....	61
	....	"	....	61
	....	quartz vein.......................	oligoclase, muscovite.......	5
	....	"	" tourmalin.......	*c*
	....	"	muscovite "	*c*
	....	"	" "	*c*
117	xx	in mica schist.....................	muscovite	43

NEW YORK

NO.	LOCALITY	SPECIES	DESCRIPTION
118	Between 42d and 51st st. and 4th and 5th av	cyanite	
119	49th st. and 1st av	beryl	
120	Between 54th and 62d st., 10th av. to river	amphibole	hydrous anthophyllite
		serpentine	dark green
121	55th–56th st. and 1st–3d av	siderite	sphaerosiderite
122	69th–70th st. and 2d av	ilmenite	
		garnet	
123	64th st. and 10th av	stilbite	small sheaflike aggregates
124	65th st. and Boulevard	garnet	large, handsome crystals
		orthoclase	crystals
125	10th av	vesuvianite	
		garnet	
126	85th-86th st. and 9th-10th av	siderite	sphaerosiderite
		albite	small fine crystals
127	95th-105th st. and 3d-Lexington av	ilmenite	
		garnet	
		stilbite	
		datolite	
128	100th-101st st. and 5th av	epidote	granular, decomposed
		albite	small fine crystals
		ilmenite	thin plates
		chabazite	translucent flesh-colored crystals
129	102d st. and 4th av	garnet	crystals
		tourmalin	black
130	4th av. tunnel excavations	stilbite	radiated aggregates
		harmotome	small brown crystals
		apophyllite	
		natrolite	
131	120th st. and Hudson river	staurolite	small crystals
132	115th-122d st. and 4th-5th av	dumortierite	azure blue
		sillimanite	fibrolite
133	138th st. and 11th av	epidote	
134	155th st. and 10th av	xenotime	small well modified crystals
		monozite	
		zircon	small acutely terminated crystals
		garnet	" rough crystals

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
118	....	in hornblende schist..................	oligoclase, quartz, garnet....	43
119	x	"	....	161
120	....	" mica schist........................	serpentine..................	5, 43
	....	"	amphibole..................	43
121	....	"	....	*c*
122	....	"	orthoclase..................	*c*
	....	"	"	*c*
123	....	"	pyrite.....................	*e*
124	xx......	"	albite.....................	*e*
	....	"	muscovite..................	*e*
125	....	granite boulder......................	orthoclase, garnet..........	*c*
	....	"	vesuvianite................	*c*
126	....	in crystalline schist..................	muscovite..................	*c*
	....	"	"	*c*
127	....	in mica schist........................	garnet, albite..............	*c*
	....	"	ilmenite...................	*c*
	....	on "	datolite....................	5
	....	"	stilbite....................	5
128	....	in "	mica......................	*w*
	....	"	on epidote.................	*w*
	....	in hornblende schist..................	clinochlore.................	*e*
	....	"	"	*e*
129	....	in mica schist........................	tourmalin..................	*e*
	....	"	....	*e*
130	....	on "	harmotome.................	5, 8
	....	"	stilbite etc................	5
	....	"	"	8
	....	"	"	8
131	....	in mica schist......................	garnet.....................	5, 43
132	xx......	" pegmatite vein....................	oligoclase, quartz..........	43, 49, 165
	....	" mica schist........................	....	43
133	....	" hornblende schist..................	....	43
134	x.......	" pegmatite vein....................	monozite..................	138, 170
	....	"	zircon, garnet..............	138
	....	in pegmatite vein....................	garnet, quartz..............	*e*
	....	"	zircon, quartz..............	*e*

NEW YORK

NO.	LOCALITY	SPECIES	DESCRIPTION
135	159th st. and 11th av	beryl	small opaque crystals
136	Washington h'ts 171st st. & 11th av	xenotime	small yellowish brown crystals
		monozite	small crystals and parallel growths
		zircon	small, slender, prismatic crystals
		dumortierite	filiform inclusions and fibrous
		muscovite	large crystals
		autunite	
137	176th-178th st. and 11th av	rutile	
		tourmalin	black
		garnet	almandite
138	180th st. & 10th av. (C. A. shaft 26)	serpentine	
		rutile	
139	200th st. and 10th av	cyanite	light yellow
140	Fort George	tourmalin	black
		muscovite	green rhombic crystals
		garnet	grossularite
		titanite	greenish yellow crystals
		orthoclase	crystallized
		oligoclase	moonstone
		zircon	minute crystals
		amphibole	hornblende and actinolite
		malachite	radiating tufts
		stilbite	sheaflike aggregates
		epidote	small brilliant crystals also gran'lar
141	½ m. s. of Kings bridge	amphibole	tremolite
		prochlorite	
		titanite	brown and black
142	Inwood	amphibole	hydrous anthophyllite
		tourmalin	small brown crystals
		pyroxene	
143	Kings bridge (ship canal)	pyrite	small brilliant crystals
		rutile	acicular, striated crystals
		pyroxene	malacolite
		tourmalin	green and brown prisms trigonal habit
		amphibole	tremolite

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
135	....	in pegmatite vein....................	quartz..............	*e*
136	x......	"	monozite, tourmalin........	82
	x.......	"	xenotime, tourmalin.......	82
	....	'	"	82
	....	....	"	82
	....	"	"	82
	....	"	quartz, muscovite..........	82
137	....	in mica schist......................	calcite....................	*c*
	....	" pegmatite vein	quartz, orthoclase..........	*e*
	....	"	"	*e*
138	....	....	....	131
	....	in crystalline limestone...............	pyrite....................	*e*
139	....	in pegmatite vein..................	orthoclase.................	*e*
140	....	"	" quartz...........	*e*
	xx	"	"	*e*
	....	"	" muscovite	*e*
	x.......	"	"	*e*
	....	"	muscovite, tourmalin.......	*e*
	....	"	quartz........	*e*
	....	"	" tourmalin.... . . .	*e*
	....	"	orthoclase, quartz..........	*e*
	x.......	'	"	*e*
	....	"	"	*e*
	....	"	"	*e*
141	....	in dolomitic limestone..............	graphite..................	5
	....	"	amphibole............. ..	5
	....	"	"	5
142	....	"	serpentine	43
	....	"	....	43
	....	....	....	*m*
143	x.......	in dolomitic limestone..............	rutile, amphibole...........	5, 43, 133
	....	"	quartz, dolomite...........	5, 133
	.. ..	"	tourmalin, muscovite.......	43
	....	'	amphibole pyrite...........	5, 43
	....	"	rutile....................	5, 43

NEW YORK

NO.	LOCALITY	SPECIES	DESCRIPTION
	Kings bridge (ship canal)	muscovite	pale green, transparent crystals
		quartz	clear and smoky crystals
		dolomite	crystals and massive
144	1m. n.e. Central bridge	clinochlore	green scales
145	Tremont (H. R. R. cut)	kaolinite	gray, red and yellow
146	Morrisania	tourmalin	brown
147	Spuyten Duyvil	amphibole	asbestos
148	West Farms	titanite	small, reddish brown prisms
		epidote	
		amphibole	tremolite
		chabazite	crystals lining walls of seams
		heulandite	"
		stilbite	"
		apatite	
		garnet	

NIAGARA

NO.	LOCALITY	SPECIES	DESCRIPTION
	Lewiston		
149		epsomite	
		calcite	lining geodes
		chalcopyrite	
	Lockport		
150	Lockport (canal cutting)	celestite	lamellar, white and bluish white, opaque to transparent. Lining geodes
		calcite	white and yellow dogtooth spar
		gypsum	selenite and snowy
		anhydrite	blue, massive
		fluorite	occasionally in cubes
		dolomite	white & pink crystals lining geodes
		sphalerite	honey and wax yellow crystals, often transparent
	Niagara		
151	Niagara Falls	calcite	crystals lining geodes
		dolomite	pink to white crystals
		fluorite	
152	Niagara Falls, Goat island	sphalerite	in imperfect crystals

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
	....	in dolomitic limestone	amphibole, pyrite	5, 43, 133
	....	"	dolomite pyrite	133, *c*, *e*
	....	"	quartz etc	5, 133
144	....	"	....	43
145	....	"	....	123, 126
146	....	in pegmatite vein	....	*e*
147	....	" mica schist	....	43
148	....	granite dikes	epidote, amphibole	5, 43
	....	"	amphibole, orthoclase	5, 43
	....	"	quartz etc	5, 43
	....	"	stilbite, heulandite	5, 43
	....	"	chabazite, stilbite	5, 43
	....	"	heulandite	5, 43
	....	in mica schist	garnet, muscovite	5, 43
	....	"	muscovite	5, 43

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
149	....	on limestone	....	43
	....	in "	....	5
	....	"	malachite (?)	5
150	x	in Niagara limestone	calcite, dolomite etc	5, 43, *k*
	xx	"	dolomite, celestite etc	43, *k*
	x	"	" anhydrite	5, 43, *k*
	x	"	calcite, gypsum	5, 43, *k*
	x	"	celestite "	5, 43, *k*
	x	"	calcite,celestite,gypsum	5, 43, *k*
	....	"	....	5, 43
151	x	in Niagara limestone	dolomite, celestite	43
	x	"	calcite, celestite, gypsum	5, 43
	....	"	"	43
152	....	in Lockport limestone	....	5, 43

ONEIDA

NO.	LOCALITY	SPECIES	DESCRIPTION
	Boonville		
153	near Boonville w. bank Dry Sugar river	calcite	prismatic and nail head crystals ..
		wollastonite....	....
		pyroxene......	coccolite......................
		garnet.........	....
	Kirkland		
154	Clinton, near Hamilton College.......	sphalerite......	yellow, nearly transparent crystals
		strontianite....	in geodes, coating celestite........
		celestite.......	in geodes.. ....
155	Elliott and Paddon mines...........	hematite.......	oolitic.....................
	New Hartford		
156	Davis ore bed......................	hematite.......	oolitic......................
		wollastonite....	fibrous......................
	Rome		
157	near Rome.........................	sphalerite......	yellow, massive...............
	Vernon		
158	near Vernon........................	"	" ....
	Verona		
158a	Verona	hematite	oolitic......................

ONONDAGA

NO.	LOCALITY	SPECIES	DESCRIPTION
	Camillus[1]		
159	Camillus railroad cut..............	gypsum	selenite and fibrous.............
		sulfur.........	small masses in beds of earthy gypsum.....................
		calcite.........	small incrusting crystals & fibrous.
	Manlius		
160	Fayetteville 1m. n. of town...........	gypsum........	occasionally in crystals, selenite...
		fluorite........	deep purple cubes..............
	Salina		
161	Liverpool..........................	gypsum........	fibrous......................
162	Syracuse...........................	halite.........	brine solution from wells etc......
		serpentine.....	....
		perofskite......	....
		celestite.......	....
		gypsum........	selenite......................
		barite.........	interlaced plates...............

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
153	x	veins in limestone		43
	x	in boulders	garnet pyroxene	5, 43
	x	"	" wollastonite	5, 43
		"	pyroxene "	5, 43
154		in shale and sandstone	hematite	5
		" Clinton and Niagara limestone	celestite	43, 168
		"	strontianite	43
155	*†	in shale and limestone		149, 194
156	*	"		149, 194
		"		71
157				5
158				5
158a	*†	Clinton shale and limestone		149

COUNTY

159		in Salina waterlime	sulfur	5, 43
		"	gypsum	5
		"	"	43
160		"	fluorite	5, 43, *p*
		"	gypsum	5, 43
161		in Salina		186
62	*	"		66, 121, 192
	x	"	perofskite	225, 226
		"	serpentine	226
		"	gypsum, barite	43
		"	celestite "	43
		"	gypsum celestite	5, 43

ONTARIO

The Devonian rocks of this county have been suc-

ORANGE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Blooming Grove		
163	Craigsville	quartz	crystals and heliotrope
164	½m. n.w. Washingtonville	labradorite	
	Cornwall		
165	Deer hill 3m. s. of Cornwall	ilmenite	
		serpentine	
	Highlands		
166	Bog Meadow pond 3m. w. of W. Point	zircon	white, reddish brown & black
		chondrodite	granular
		spinel	black and green
		orthoclase	white, opalescent
		epidote	massive and somewhat fibrous
		pyroxene	coccolite
		amphibole	
167	4m. s.e. Woodbury furnace	"	
		calcite	
		fosterite	boltonite
		magnetite	
		spinel	
168	Forest of Dean mine	pyroxene	coccolite, sahlite
	5m. s.w. West Point	forsterite	boltonite
		spinel	large crystals, black and green
		magnetite	
		amphibole	pargasite
		wernerite	
		zircon	reddish brown and black
169	West Point	molybdenite	
		amphibole	tremolite, actinolite
		tourmalin	
		garnet	common
		epidote	
		pyroxene	diallage
		orthoclase	in crystals often flesh-color
		mica	
		wernerite	large, white, compact masses
		titanite	
		allanite	tabular crystals

COUNTY

cessfully drilled for natural gas in several localities.

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
163	....	veins in slate........................	....	5, 43
164	....	....	....	43, 74
165	....	....	....	5, 43
	....	....	....	5, 43
166	x	in crystalline limestone...............	chondrodite, spinel.........	5, 43
	x	"	spinel etc..................	5, 43
	x	"	chondrodite, zircon	5, 43
	x	"	epidote	5
	x	"	orthoclase	5, 43
	....	"	....	43
	....	"	....	5, 43
167	....	in gneiss limestone contact...........	spinel etc..................	5, 43
	....	"	amphibole................	74
	x	"	....	74
	....	"	....	74
	....	"	....	74
168	x	in crystalline limestone	spinel wernerite	74, 43
	....	"	pyroxene..................	74
	x.......	"	"	43, 74, 5
	*.......	"	spinel, pyroxene...........	74, 149, 194
	....	"	"	43,74
	....	"	"	43, 74
	....	"	"	43, 74
169	....	in gneiss..............................	tourmalin..................	35
	x	" syenite..............................	....	35
	....	" gneiss..............................	molybdenite...............	35
	....	"	tourmalin..................	35
	....	"	" pyroxene........	35
	....	"	" titanite..........	35, 95
	x	"	"	5, 43
	x	"	"	43
	....	"	pyroxene..................	5, 43
	x	"	"	43
	....	"	" wernerite	43, 10

ORANGE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Highlands (*continued*)		
170	West Point, Constitution island.	molybdenite . . .	. . . .
		magnetite	. . . .
	Monroe		
171	O'Neil mine 1m. e. Mombasha.	magnetite	large grains. . . . .
	2m. s.w. Turners.	garnet.	colophonite. . . . .
		pyroxene.	large, greenish black crystals. . . . .
		"	coccolite, green. . . . .
		amphibole.	hornblende, amianthus. . . . .
		serpentine.	yellow and black. . . . .
		dimagnetite.	perhaps a magnetic pseudomorph after ilvaite. . . . .
		biotite.	. . . .
		hortonolite.	. . . .
172	Clove mine near Turners.	biotite.	. . . .
		amphibole.	hornblende, asbestos. . . . .
		orthoclase.	. . . .
		serpentine.	. . . .
		hydrophite.	jenkinsite. . . . .
		calcite.	. . . .
		chromite.	. . . .
	Mt Hope		
173	Erie mine, Guymard.	galena.	. . . .
	Tuxedo		
174	Tuxedo Park.	epidote.	. . . .
175	½m. e. Arden.	pyroxene.	green, grayish green and gray crystals. . . . .
		biotite.	anomite. . . . .
		chondrodite. . . .	light yellow grains. . . . .
		spinel.	black and green. . . . .
		wernerite.	meionite. . . . .
		amphibole.	hornblende. . . . .
176	3m. s.e. Arden.	pyroxene.	salite, coccolite . . . .
177	Greenwood furnace, Arden.	"	diopsid. . . . .
		chondrodite. . . .	. . . .
		biotite.	anomite. . . . .
		spinel.	. . . .

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
170	....	in gneiss........................	....	35
	....	"	....	35
171	x*†.....	"	serpentine, pyroxene	149
	x......	"	"	5,43,74,149
	....	"	magnetite, garnet..........	5, 74
	....	"	"	5, 74, 149
	....	"	"	5, 43, 74
	....	"	"	5, 43, 74
	....	"	"	43, 181
	xx	"	"	43
	....	"	on pyroxene...............	139
172	....	in limestone......................	serpentine, amphibole etc....	5
	....	"	biotite....................	5, 43
	....	"	....	5
	....	"	....	5
	....	"	....	191
	....	"	....	5
	....	"	....	5
173	*†......	in limestone......................	....	5
174	x.......	....	....	5, 43
175	xx......	in crystalline limestone	mica.....................	5, 43
	xx......	"	pyroxene.................	5
	x.......	"	spinel....................	5, 43
	x.......	"	chondrodite...	5, 43
	x.......	"	pyroxene, mica	5, 43
	....	"	"	5, 43
176	....	"	....	5, 43
177	xx.. . .	in gneiss........................	wernerite, spinel...........	51, 43
	x.......	"	spinel....................	43
	xx......	"	wernerite, pyroxene........	43
	x.......	"	"	43

ORANGE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Tuxedo (*continued*)		
	Greenwood furnace, Arden	wernerite......	....
		amphibole.....	....
		ilmenite.......	....
	Warwick		
178	1m. s.w. Amity....................	spinel.........	green, black, brown and red very large crystals................
		chondrodite....	rounded grains and crystals.......
		corundum......	white, blue and reddish crystals...
		tourmalin......	yellow and cinnamon crystals.....
		clinochlore.....	leuchtenbergite................
		phlogopite.....	....
		fluorite........	....
		amphibole.....	large and perfect crystals.........
		magnetite	in scattered grains..............
		ilmenite.......	interesting crystals.............
		garnet.........	grossularite..................
179	½m. s.e. Amity	spinel.........	large octahedral crystals.........
		corundum.....	bluish white..................
		amphibole.....	hornblende....................
180	Amity..........................	spinel.........	grayish red, twinned octahedrons..
		warwickite.....	....
		seybertite......	clintonite....................
		talc...........	common and foliated varieties....
		ilmenite.......	fine crystals..................
		garnet.........	cinnamon brown crystallized and massive....................
		wernerite......	milk white crystals, dendritic surfaces.....................
		pyroxene......	light brown crystals, leucaugite...
		"	augite and coccolite............
		enstatite.......	bronzite.....................

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
	x.......	in gneiss..........................	pyroxene.................	43
	....	"	ilmenite..................	43
	....	"	amphibole................	43
178	xx......	in granular limestone and serpentine....	chondrodite, hematite......	5, 43, 176
	x.......	" ...	spinel, tourmalin...........	43
	x.......	" ...	" rutile................	5, 43
	x.......	in calcite......	"	5, 43, 74
	....	"	amphibole, phlogopite......	43
	....	"	" fluorite.........	43
	....	"	spinel, tourmalin...........	43, 74
	x.......	"	phlogopite, graphite........	5, 43,74,176
	....	"	chondrodite............ ..	43
	x.......	"	spinel....................	176, 74
	....	"	amphibole etc.............	74
179	x.......	in crystalline limestone..............	corundum.................	74, 176
	....	"	amphibole spinel...........	74, 176
	....	"	spinel, corundum	74, 176
180	xx......	" and serpentine..	ilmenite..................	5, 43, 74, 176, 212
	....	"	"	43, 178, 190
	x.......	"	"	5, 43, 74
	xx......	"	" seybertite..........	5, 43
	....	"	spinel....................	5, 43, 85
	x.......	in crystalline limestone..............	pyroxene.................	43, 176
	x.......	"	" titanite.........	5, 43, 74, 176
	xx......	"	calcite, seybertite..........	5, 41, 43, 119, 159
	....	"	wernerite, titanite..........	74, 176
	....	"	spinel, pyroxene...........	57, 176

NO.	LOCALITY	SPECIES	DESCRIPTION
	Warwick (*continued*)		
	Amity (*continued*)	amphibole	pargasite, amianthus
		vesuvianite	grayish and yellowish brown crystals, xanthite
		titanite	in small crystals
		zircon	large brown crystals (rare)
		orthoclase	crystallized
		tourmalin	clove brown
		rutile	brown to pale red crystals
		chondrodite	pink
181	2m. s.w. Amity	apatite	fine crystals, emerald and bluish green
		rutile	dark blue terminated prisms.
182	2m. s.e. Amity	epidote	rich grass-green crystals
183	2m. w. Amity	rutile	black, gray and reddish brown crystals
184	Edenville	chondrodite	blood-red, orange and buff
		titanite	light brown crystals
		tourmalin	gray, bluish, green and black
		scorodite	small crystals and druses
		arsenopyrite	crystals and massive
		leucopyrite	abundant
		warwickite	hair-brown grains
		yttrocerite	purple
		sphalerite	opaque, black
		vesuvianite	
		quartz	hornstone
185	1m. n. of Edenville	orthoclase	crystallized
		fluorite	
		amphibole	tremolite and hornblende
		vesuvianite	
		tourmalin	
		titanite	
		spinel	
		zircon	red and white
		orpiment	slight traces

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
	....	in crystalline limestone..............	spinel, pyroxene...........	74, 176
	x.......	"	"	5, 43, 74, 176, 212
	....	"	"	5, 43, 74, 176
	x.......	"	wernerite garnet...........	43, 176
	x.......	"	"	74
	x.......	"	amphibole, rutile...........	5, 43
	....	"	tourmalin and quartz	5, 43
	....	"	calcite and serpentine......	74, 141, 176
181	x.......	in crystalline limestone..............	pyroxene.................	5, 43, 176
	....	"	spinel, chondrodite.........	5, 43
182	xx......	in quartz	....	5, 43
183	....	" crystalline limestone..............	spinel corundum...........	5, 43
184	xx......	"	spinel...	5, 43, 141
	....	"	hornblende...............	5, 43
	....	"	"	5, 43
	....	"	arsenopyrite.....	5, 43, 74
	....	"	scorodite, gypsum..........	43, 74
	x.......	"	hornblende................	43
	x.......	"	chondrodite...............	43, 178
	xx......	"	silvery muscovite..........	43
	.. ..	"	....	c
	....	"	....	43
	....	"	....	43
185	......	limestone granite contact............	amphibole spinel......	74
	....	"	....	74
	....	"	....	74
	....	"	....	74
	....	"	....	74
	....	"	....	74
	....	"	....	74
	....	"	....	74
	....	"	....	74

NO.	LOCALITY	SPECIES	DESCRIPTION
	Warwick (*continued*)		
186	southern base of Mt Eve 2½m. n. of Edenville	amphibole	edenite, dark hair-brown crystals.
		pyroxene	gray crystals
		wernerite	
		zircon	chocolate brown crystals
		orthoclase	
		spinel	
		fluorite	purple
187	1m. n. w. Edenville	pyroxene	augite
		amphibole	dark green, gray or brown crystals
		muscovite	six sided and rhombic prisms
		rutile	
		chondrodite	
188	4m. w. Edenville	ilmenite	
189	1m. e. Edenville	rutile	
190	1m. s. Edenville	amphibole	dark green, gray or brown crystals
191	Warwick	spinel	soft, pseudomorphous crystals
		serpentine	sometimes in large pseudomorphous crystals
		ilmenite	crystals
		pyroxene	coccolite
		amphibole	
		warwickite	
192	Rocky hill 3m. s.e. Warwick	magnetite	
		marcasite	terminated crystals
		titanite	large grayish brown crystals
		zircon	brown
		rutile	square terminated prisms
		wernerite	
		orthoclase	interesting crystals
		tourmalin	
		seybertite	clintonite
193	2 m. e. Warwick	magnetite	
		marcasite	
		arsenopyrite	
		pyrite	in cubes
		molybdenite	in irregular plates

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
186	xx. . . .	in crystalline limestone.	wernerite, pyroxene.	5, 43, 176
	x	"	" zircon.	5, 43, 176
	. . . .	"	pyroxene.	5, 43, 176
	x	"	" wernerite.	5, 43, 176
	. . . .	"	. . . .	5, 43
	. . . .	"	. . . .	176
	. . . .	"	. . . .	176
187	x	"	amphibole.	5, 43
	x	"	pyroxene mica	5,43,74,176
	. . . .	"	"	5, 43, 176
	. . . .	"	"	5, 43, 176
	. . . .	"	. . . .	74, 141
188	. . . .	gneiss limestone contact	spinel chondrodite	5, 43
189	. . . .	in limestone boulders.	amphibole.	5, 43
190	. . . .	" crystalline limestone	titanite chondrodite	5, 43
191	xx	"	serpentine	5, 43
	xx	"	pyroxene spinel.	5, 43
	. . . .	"	spinel, chondrodite.	5, 43
	. . . .	"	amphibole, spinel.	5, 43
	. . . .	"	pyroxene, spinel.	5, 43
	. . . .	"	"	178, 190, *a*
192	*†.	in gneiss.	. . . .	194
	. . . .	"	magnetite	176
	. . . .	"	zircon etc.	5, 43
	. . . .	"	orthoclase, tourmalin.	43, 176
	. . . .	"	zircon.	176
	. . . .	"	" amphibole	5, 43
	xx	"	tourmalin zircon	5, 43
	. . . .	"	orthoclase	43
	x	"	"	43
193	*†.	in limestone.	garnet.	74, 176
	. . . .	"	zircon.	5, 43
	. . . .	"	mica, pyrite.	43
	. . . .	"	marcasite.	5
	. . . .	"	rutile, zircon, pyrite.	5, 43

ORANGE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Warwick (*continued*)		
	2 m. e. Warwick...................	rutile..........	octagonal prisms................
		quartz.........	small ferruginous crystals........
		garnet.........	....
194	Sterling mines, Sterling lake.........	magnetite......	granular......................
		amphibole.....	crystals......................
		pyroxene......	' ....
		epidote........	small crystals..................
		orthoclase......	red and white.................
		tourmalin......	....
	Woodbury		
195	Queensbury forge 2½ m. s. w. Fort Montgomery.....................	spinel.........	black and green................
		sillimanite.....	monrolite, bucholzite...........
		garnet.........	colophanite....................
		rastolite.......	....
		amphibole.....	....
		ilmenite.......	good crystals..................
		pyrrhotite.....	....
		pyrite.........	massive.......................
196	Bradley mine n. Cedar pond..........	magnetite......	crystals embedded in calcite......
		pyrrhotite.....	....
		apatite........	crystals embedded in calcite.....
		pyroxene......	granular and short green crystals..
		titanite........	crystals embedded in calcite.....
197	Fall hill 3 m. e. Central Valley.........	wernerite......	white and bluish................
198	Twin lakes (Two ponds).............	pyroxene......	gray to brown prismatic crystals..
		wernerite......	large reddish white crystals.......
		chondrodite....	granular, light yellow...........
		zircon.........	large crystals..................
		amphibole.....	green actinolite and hornblende...
		titanite........	abundant in large crystals........
		apatite........	....

ORLEANS

The rocks of this county afford no recorded mineral

OSWEGO

The rocks of this county have been successfully drilled

OTSEGO

The rocks of this county afford no recorded mineral

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
	x	in limestone	zircon	5, 43
		"		5, 43
		"		74
194	*	in gneiss	apatite	149, 194
		"	pyroxene	160
		"	epidote	160
		"	pyroxene	160
		"	magnetite, tourmalin	160
		"	quartz	160
195	x	"	mica, garnet, magnetite	5, 43
		"	"	5, 43
	x	"	mica, spinel etc	5, 43
		"		43
		in serpentine and white limestone		43
		"	spinel, chondrodite, rutile	5, 43
	x	"		43
		"		5, 43
196	*	in gneiss	calcite	160
		"		160
		vein in gneiss	calcite, augite	160
		"	apatite, titanite etc	160
		"	pyroxene, apatite	160
197		in gneiss	lamellar pyroxene	5, 43
198	xx	in crystalline limestone	wernerite, zircon etc	5, 43
	xx	"	pyroxene, titanite	5, 43
	x	"	spinel	5, 43
	x	"	wernerite, pyroxene	5, 43
		"	"	5, 43
		"	"	5. 43
		"	"	5, 43

COUNTY

localities of sufficient importance to note in this list.

COUNTY

for natural gas; no notable mineral localities are recorded.

COUNTY

localities of sufficient importance to note in this list.

PUTNAM

NO.	LOCALITY	SPECIES	DESCRIPTION
	Carmel		
199	near Carmel, boulder in road........	epidote........	sharp, well defined crystals.......
200	2m. s. Carmel.....................	"	translucent crystals and massive..
201	Mahopac group of mines............	magnetite......	medium fine grained.............
	Kent		
202	2m. n.e. Carmel....................	amphibole.....	actinolite.....................
203	Brown's quarry 4m. n.w. Carmel......	arsenopyrite....	in good crystals ....
		amphibole.....	radiated anthophyllite..........
	Patterson		
204	1m. w. Towners....................	pyroxene......	grayish white crystals...........
		calcite.........	scalenohedral crystals...........
		amphibole.....	asbestos and tremolite...........
		dolomite.......	....
		pyrite.........	massive.......................
	Philipstown		
205	Cold Spring......	titanite........	....
		epidote........	....
		pyroxene......	....
206	Hustis quarry 4m. n.e. Cold Spring....	amphibole.....	tremolite, amianthus...........
		serpentine......	many varieties..................
		titanite........	....
		pyroxene......	diopsid, green coccolite..........
		wernerite......	small white opaque crystals.......
		dolomite.......	semiopaline, conchoidal fracture...
207	Cotton rock 3½m. s. of Garrisons (this locality has been obliterated by the N.Y.C.R.R. embankment)	serpentine......	....
		amphibole.....	silky amianthus................
		pyroxene......	diallage and augite.............
		stilbite........	crystals and fanlike groups.......
		laumontite.....	occurs sparingly...............
	Putnam Valley		
208	Denny and Todd mines 6m.n.e.Peekskill	magnetite......	....
		chromite.......	....
		calcite.........	small crystals on magnetite.......
209	Phillips' ore bed (this bed outcrops at intervals in the towns of Philipstown and Putnam Valley following a valley formerly known as Canopus hollow)..................	magnetite......	....
		pyrite	massive.......................
		amphibole.....	actinolite......................
		opal..........	hyalite in thin coatings..........

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
199	x	in granite boulder		ε
200		in gneiss	amphibole, garnet	5, 43
201	*†	"		149, 194
202		in gneiss		5
203		"	amphibole	43
		serpentine in gneiss	arsenopyrite, epidote	5, 43
204	xx	in dolomitic limestone		5, 43
	x	"	asbestos	43
	x	"	calcite	5, 43
		"	"	43
		"		5,43
205	†	in gneiss		5, 43
		"		5, 43
		"		5, 159
206	*†	in crystalline limestone	serpentine	5, 43, *g*
	x*†	"		5, *g*
		"		43, *g*
		"	serpentine, apatite	5, 159
		"	titanite, apatite, quartz	5, 43, *g*
	*†	"		5, 43
207	†	"	amphibole	5, 43
	†	"	serpentine	5, 43
	†	"	"	5, 43
	†	"		5, 43
	†	"		5, 43
208	*†	gneiss limestone contact	chromite	43, 149, 194
		"		43
		"	magnetite chromite	5, 43
209	*†	in gneiss		5, 43, 194
		"	magnetite, amphibole	5, 43
		"	"	5, 43
		on "		43

PUTNAM

NO.	LOCALITY	SPECIES	DESCRIPTION
	Southeast		
210	Tilly Foster mine 2m. n.w. Brewster...	chondrodite....	deep red crystals, highly modified
		clinohumite....	"
		humite........	"
		magnetite......	dodecahedral crystals and massive
		dolomite.......	....
		serpentine	light and dark green, mottled with red...........................
		"	pseudomorphs in many forms.....
		brucite........	crystallized and pseudomorph after dolomite....................
		enstatite......	....
		clinochlore.....	in large crystals................
		prochlorite.....	....
		biotite.........	....
		amphibole.....	actinolite, light green fibrous .....
		pyrrhotite	....
		fluorite........	colorless to purple crystals ....
		albite	....
		epidote........	small crystals..................
		titanite........	transparent greenish crystals often twinned....................
		hydrotalcite....	white fibrous..................
		calcite.........	scalenohedral and nail head types.
		garnet.........	oil-green dodecahedral crystals....
		apatite...... ..	....
		datolite........	....
		stilbite........	....
		prehnite.......	....
		apophyllite....	....
		tourmalin......	....
		molybdenite....	....
		pyroxene......	dark green coccolite............

QUEENS

The rocks of this county are deeply covered with drift and artificially

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
210	xx.......	in gneiss........................	magnetite, clinochlore......	1, 16, 37, 38, 43, 141, 170
	x...... .	"	"	43, 141
	x........	"	"	43, 141
	x*†.....	"	serpentine, clinochlore......	43, 149, 170, 194
	x........	"	magnetite, chondrodite.....	43, 170
	x........	"	"	16, 43, 170
	x........	"	"	42, 43
	x........	"	prochlorite................	42, 43, 170
	x........	"	"	16, 43, 170
	xx.......	"	chondrodite...............	16, 43, 170
	....	"	clinochlore...............	16, 43, 170
	....	"	....	16, 43
	....	"	....	5, 16, 43
	....	"	....	43, 170
	....	"	calcite....................	43, 170
	....	"	....	43
	....	"	pyroxene, amphibole.......	43, 170
	xx.......	"	magnetite, apatite	43
	x	"	" prochlorite......	*w*
	....	"	brucite, dolomite...........	170
	....	"	....	43, 170
	x	"	....	43
	....	"	....	43
	....	"	....	43
	....	"	....	43
	x	"	....	43
	....	"	....	43, *w*
	....	"	magnetite serpentine	*w*
	....	"	hornblende, epidote........	*w*

COUNTY

made land; deep excavations may however develop mineral localities.

RENSSELAER

NO.	LOCALITY	SPECIES	DESCRIPTION
	Brunswick		
211	Lansingburg	quartz	large doubly terminated crystals
212	South Troy	"	"

RICHMOND COUNTY

NO.	LOCALITY	SPECIES	DESCRIPTION
213	Tompkinsville[a] and southward to New Dorp	serpentine[b]	red and green (slickensides)
		"	asbestos and amianthus
		talc	greenish white, foliated
		dolomite	
		brucite	white, foliated
		magnesite	massive in veins and cavities
		aragonite	minute needlelike crystals
		chromite	minute octahedrons
		pyrolusite	thin dendrites
		deweylite	
		anhydrite	massive
214	iron mines w. of Concord and w. of Garretsons	limonite	oolitic and spongy
		quartz	green quartz in small crystals
215	Rossville on shore of Arthur kill	lignite	
		pyrite	crystals and nodules

ROCKLAND

NO.	LOCALITY	SPECIES	DESCRIPTION
	Haverstraw		
216	Ladentown 1½m. n.w. of Pomona	cuprite	
		malachite	
		zircon	brilliant brown to black crystals
217	Haverstraw	amphibole	hornblende in small crystals
	Orangetown		
218	Piermont, excavations for the Erie R. R.	datolite	
		stilbite	in minute crystals
		apophyllite	
		pectolite	
		prehnite	

a A fresh exposure occurs in Westervelt av. between 1st and 2d av.
b Serpentine also occurs in frequent outcrops along the ridge extending southwest from

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
211	x	....	....	*e*
212	....	....	....	*e*

AND BOROUGH

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
213	....	serpentine rock	talc, brucite etc	5, 43, 94
	x	"	"	5,43,94,144
	x	"	serpentine, magnesite	5, 43
	x	"	"	5, 43
	....	"	"	5, 43
	....	"	serpentine, brucite	5, 43
	....	"	"	43
	....	"	serpentine	*w*
	....	"	on talc	*w*
	....	"	serpentine, brucite	*w*
	....	"	talc, brucite	*w*
214	*†	serpentine	yellow clay and quartz	18, 23, 67 149
	....	"	limonite	67
215	....	in clay	pyrite	5, 43
	....	"	lignite	5, 43

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
216	....	in red Triassic shale	malachite	5, 43
	....	"	cuprite	43
	....	in granite boulder	....	5, 43
217	....	" shale	....	5
218	....	in diabase	apophyllite, stilbite	43
	....	"	datolite, zeolites	5, 43
	....	"	"	5, 43
	....	"	"	5, 43
	....	"	" calcite	5, 43

Tompkinsville to New Dorp.

ROCKLAND

NO.	LOCALITY	SPECIES	DESCRIPTION
	Orangetown (*continued*)		
	Piermont, excavations for the Erie R. R. (*continued*)	thomsonite	
		chabazite	
		calcite	in minute crystals
		tourmalin	
	Stony Point		
219	Dunderberg mine n. side Dunderb'g mt	magnetite	lean ore
220	Stony Point, north shore	zoisite	
		pyroxene	green augite
		amphibole	hornblende, light green
		titanite	
		pyrite	small crystals
		chrysolite	
		garnet	
		staurolite	minute crystals
221	Tomkins Cove	calcite	white and yellowish crystals
		barite	minute tabular crystals
222	2½m. n.w. Grassy Point	amphibole	radiated and interlaced actinolite
		orthoclase	minute crystals
		epidote	small granular masses

ST LAWRENCE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Canton		
223	Pyrite mines 2m. s. Canton	pyrite	massive
		chalcopyrite	
		hematite	
		calcite	
		serpentine	
		talc	rensselaerite
		tourmalin	brown
		titanite	
		pyroxene	
	De Kalb		
224	3m. s. DeKalb Junction	"	diopsid, transparent crystals
		datolite	rare
225	5m. s.w. DeKalb Junc. (Mitchel farm)	pyroxene	diopsid
		calcite	crystallized and massive
		quartz	

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
	....	in diabase........................	zeolites, calcite............	5, 43
	....	"	"	5, 43
	....	"	"	5, 43
	....	"	....	*a*
219	*†......	" gneiss........................	pyrite....................	194
220	....	" diorite limestone contact..........	amphibole, pyroxene.......	5, 45, 228
	....	"	"	45, 96, 159, 228
	....	"	pyroxene.................	5,45,96, 228
	....	"	amphibole wernerite.......	159, 228
	....	on peridotite........................	calcite	*e*
	....	in "	....	96, 44
	....	" diorite........................	....	44
	....	" mica schist........................	....	44
221	x.......	" Stockbridge limestone............	....	5, 43
	....	"	calcite	5
222	....	in limestone........................	epidote etc................	5
	....	"	amphibole, epidote.........	5
	....	"	orthoclase "	5

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
223	x*......	gneiss limestone contact.............	chalcopyrite	43
	....	"	pyrite....................	43
	....	"	....	43
	x	"	....	43
	....	in granular limestone..............	....	43
	....	"	....	43
	....	"	....	43
	....	"	....	43
	....	"	....	43
224	xx	gneiss limestone contact	pockets in clay	5, 43, 151
	....	"	pyroxene.................	43
225	xx	in clay pockets in talc	calcite....................	5, 43, 151, *w*
	....	"	pyroxene quartz...........	*w*
	....	"	....	*w*

ST LAWRENCE

NO.	LOCALITY	SPECIES	DESCRIPTION
	De Kalb (*continued*)		
226	3m. w. De Kalb Junction	talc	massive fibrous
		tourmalin	colorless glassy crystals
		amphibole	dark green hornblende
		phlogopite	
		serpentine	
227	near Osborn's lake	fluorite	large cubic crystals
		tourmalin	
		calcite	crystals
		barite	
		amphibole	white and gray tremolite
		phlogopite	
228	Richville	barite	long tabular crystals
	Edwards		
229	Talcville, talc mines	talc	massive, fibrous
		amphibole	hexagonite schist of interlaced crystals
		pyrolusite	small but perfect dendrites
		enstatite	rather rare
230	Anthony mine 2m. s. Edwards	amphibole	actinolite, tremolite
		wernerite	
		apatite	
		phlogopite	light green and sea-green plates
		hematite	
		magnetite	
		serpentine	
	Fine		
231	Scott farm	oligoclase	crystals, moonstone
		pyroxene	brilliant crystals
		zircon	
		titanite	
		fluorite	
		calcite	
		pyrite	
232	Benson mines	magnetite	
233	Clifton mines	"	

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
226	*.......	in limestone	amphibole................	*w*
	xx	"	" pyroxene........	43
	x	"	pyroxene.................	43,
	x	"	" amphibole........	43
	....	"	....	43
227	x	in gneiss.........................	calcite	43
	x	"	" fluorite	43
	....	"	fluorite	43
	....	"	calcite, fluorite	43
	....	"	phlogopite................	5, 43
	....	"	amphibole etc.............	43
228	xx	in limestone......................	....	24, 43
229	*.......	in gneiss.........................	....	136, 137, 171, 172, 200, 202, 203, 205
	xx......	in gneiss.........................	amphibole................	43, 205
	x.......	on talc...........................	....	*w*
	....	in limestone......................	amphibole.................	43, 205
230	xx......	gneiss limestone contact.............	apatite, wernerite..........	43
	....	"	" amphibole etc......	43
	....	"	"	43
	xx......	"	wernerite, apatite..........	*c*
	....	"	....	43
	....	"	....	43
	....	"	....	5, 43
231	x.......	granite limestone contact............	pyroxene.................	43, *c*
	x.......	"	oligoclase.................	43, *c*
	x.......	"	titanite..................	43
	....	"	zircon, apatite............	43
	x.......	in limestone......................	calcite, pyrite.............	43
	x.......	"	fluorite..................	43
	....	"	" calcite............	43
232	*†......	in gneiss.........................	....	149, 194
233	*†......	"	....	194

NO.	LOCALITY	SPECIES	DESCRIPTION
	Fowler		
234	Fullerville iron works	hematite	
		quartz	pyramidal crystals
		barite	tabular crystals
235	Belmont farm	sphalerite	
		galena	
	Gouverneur		
236	4½m. n. of Gouverneur	tourmalin	brown crystals highly modified
		amphibole	short green crystals, also tremolite
		pyroxene	
		apatite	large crystals
		titanite	brilliant black crystals
		phlogopite	large sheets dark brown
		pyrite	crystallized
237	1m. s.w. of Gouver. (marble quarries)	tourmalin	plentiful brown crystals
		amphibole	tremolite
		wernerite	
		serpentine	pseudomorphs and verd antique
		fluorite	etched and twinned cubes
238	1½m. n.e. of Gouverneur	garnet	almandite
239	1m. s. of Gouverneur	orthoclase	large crystals
		pyroxene	gray and dark green
		apatite	
		vesuvianite	
		titanite	
		talc	rensselaerite
		serpentine	
		fluorite	
240	Elmdale (Smith Mills), 4½m. w. Gouverneur	amphibole	massive fibrous tremolite
		vesuvianite	
		biotite	
		graphite	
		barite	crystalline
	Hammond		
241	near De Long's mills	apatite	large crystals
		zircon	large crystals containing nucleus
		orthoclase	luxoclase, white to bluish crystals

COUNTY *(continued)*

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
234	....	limestone gneiss contact.............	quartz....................	43
	x.......	"	hematite..................	5, 43
	....	"	"	43
235	....	vein traversing serpentine............	galena....................	5, 43
	....	"	sphalerite................	43
236	xx	in Grenville limestone..............	amphibole, apatite.........	5, 43
	xx	"	apatite, tourmalin.........	5, 43
	x.......	"	"	5, 43
	x.......	"	wernerite, titanite..........	5, 43, 80
	x.......	"	tourmalin, pyroxene........	5, 43
	x.......	"	....	*c*
	....	"	tourmalin, calcite..........	
237	xx	"	calcite....................	5, 43, 25
	xx	"	"	5, 43
	xx	"	....	5, 43
	xx	"	calcite....................	5, 43
	x.......	"	"	43, *c*
238	*.......	vein in gneiss......................	quartz....................	*w*
239	....	limestone granite contact............	" pyroxene...........	5, 43
	x.......	"	amphibole, tourmalin.......	5, 43, 159
	....	"	pyroxene, titanite..........	43
	....	"	....	43, 79
	....	"	apatite, pyroxene..........	43
	x.......	in limestone.......................	serpentine.................	43
	....	"	talc......................	5, 43
	....	"	....	43
240	xx......	gneiss limestone contact..............	biotite, graphite...........	43, 79
	....	"	....	43
	....	"	....	43
	....	"	....	43
	....	in limestone.......................	fluorite, calcite............	79
241	xx......	in crystalline limestone..............	wernerite, titanite..........	5, 43
	xx......	"	apatite...................	5, 43
	x.......	"	" pyroxene...........	5, 43

NO.	LOCALITY	SPECIES	DESCRIPTION
	Hammond (*continued*)		
	near De Long's mills (*continued*).....	amphibole.....	pargasite and tremolite..........
		phlogopite.....	....
		pyroxene......	grayish white and green.........
		barite.........	snow white crested variety........
		pyrite.........	crystals........................
		fluorite........	purple..........................
	Hermon		
242	Lowden mine 1m. n.e. of Hermon.....	hematite.......	....
		quartz.........	pyramidal......................
		amphibole.....	pargasite.......................
		pyroxene......	....
		tourmalin......	....
243	Dodge ore bed.....................	siderite........	bent crystals..................
		serpentine......	....
		limonite.......	bog iron ore....................
	Macomb		
244	1½m. n. Elmdale (Smiths Mills).......	fluorite........	masses of large green cubes.......
		calcite.........	Rossie type, small crystals ....
		pyrite.........	concretionary aggregates of crystals ....
245	St Lawrence Min. Co.'s mines, 1m. e. Macomb	galena.........	massive.......................
		sphalerite......	....
246	1m. n.e. Macomb..................	tourmalin......	dark brown and black...........
		pyroxene......	small glassy crystals............
		amphibole.....	....
		albite..........	peristerite.....................
		graphite.......	....
		phlogopite.....	....
		wernerite......	....
		apatite........	....
247	Ingram farm......................	tourmalin......	dark brown and black...... ....
		graphite.......	....
248	Pope's Mills......................	phlogopite.....	....
		barite.........	....

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
	x.......	in crystalline limestone...............	apatite, pyroxene..........	43
	x.......	"	"	43
	....	"	zircon, orthoclase..........	5, 159
	....	"	pyrite....................	43
	....	"	....	43
	....	"	....	43
242	*.......	in gneiss.........................	....	194
	x.......	"	hematite.................	5, 43
	....	"	....	43
	....	"	....	43
	....	"	....	43
243	....	in limestone......................	....	5, 43
	....	"	....	5, 43
	....	"	....	43
244	xx†.....	in crystalline limestone..............	calcite, pyrite..............	43, 116
	....	"	fluorite "	43, *w*
	....	in crystalline limestone..............	fluorite, calcite.............	*w*
245	*†......	veins in limestone..................	calcite....................	43, *w*
	*†......	"	galena, calcite.............	43, *w*
246	xx	in crystalline limestone..............	pyroxene, amphibole.......	43
	x	"	tourmalin "	159, *c*
	....	"	albite, pyroxene...........	43
	x	"	graphite "	43
	x	"	pyroxene, wernerite........	43
	x	"	....	43
	....	"	....	43
	....	"	....	43
247	xx	gneiss limestone contact............	graphite..................	43
	....	"	orthoclase.................	43
248	x	"	....	43
	....	"	....	43

ST LAWRENCE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Morristown		
249	Mineral point, 2m. n.e. Hammond.....	galena........	....
		sphalerite......	....
		fluorite........	....
		calcite........	large clear crystals.............
	Oswegatchie		
250	Ogdensburg........................	labradorite....	....
	Pierrepont		
251	1 m.e. West Pierrepont	tourmalin......	brilliant black crystals...........
		phlogopite.....	....
		pyroxene......	transparent, tabular crystals.....
252	farms of Wells and Vaughn..........	amphibole.....	....
		pyroxene......	....
		oligoclase......	....
253	Pierrepont........................	wernerite......	large gray and white crystals.....
		albite	peristerite.....................
		pyroxene......	....
	Pitcairn		
254	1 m. n.e. East Pitcairn	zircon.........	fine crystals....................
		microcline.....	white rounded crystals...........
		pyroxene.. ...	brilliant green crystals...........
		titanite........	pale red and brown crystals ......
		phlogopite.....	....
		gypsum........	satin spar......................
255	2 m. e. East Pitcairn...............	pyroxene......	large crystals..................
		titanite........	large pale red and brown crystals..
		fluorite........	....
		zircon.........	large, greenish, prismatic crystals.
		calcite........	....
	Potsdam		
256	boulder in road near Crary's Mills.....	orthoclase......	large crystals ....
		tourmalin......	black " ....
		biotite.........	....
		amphibole.....	....

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
249	....	vein in gneiss......................	sphalerite, calcite..........	5, 43
	....	"	galena	5, 43
	....	"	"	5, 43
	....	"	" sphalerite	5
250	....	in granite boulder..................	....	43
251	xx	limestone gneiss contact.............	quartz	43
	x	"	"	43
	....	"	" amphibole..........	43, 159
252	....	in gneiss.........................	pyroxene, oligoclase........	43
	....	"	....	43
	....	"	....	43
253	x	limestone gneiss contact.............	pyroxene.................	43, *c*
	....	"	" wernerite.........	43
	....	"	wernerite.................	43
254	xx	limestone granite contact............	microcline	43
	x	"	pyroxene	43
	x	"	microcline, zircon..........	43
	....	"	" pyroxene.......	43, 223
	....	"	....	43
	....	"	....	43
255	x	granite vein.......................	titanite, zircon............	43
	x	"	zircon....................	43, 223
	x	"	calcite...................	43
	x	"	titanite, pyroxene..........	43
	....	"	fluorite..................	43
256	x	granite boulder....................	quartz, pyroxene...........	5, 43
	x	"	....	43
	x	"	....	43
	....	"	....	43

ST LAWRENCE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Rossie		
257	Rossie lead mines 2m. s. Rossie	galena	crystallized and massive
		pyrite	crystals often highly modified
		calcite	large twinned crystals
		celestite	delicate blue
		chalcopyrite	crystals
		hematite	
		cerussite	rare
		anglesite	
		fluorite	rarely in fine octahedral crystals
258	iron mines, Somerville	hematite	laminated structure
		barite	in flattened crystals
		pyrite	crystals
		quartz	large implanted crystals
259	Somerville	spinel	rose and reddish brown
		hydrotalcite	houghite
		dolomite	
		aragonite	flos ferri
		phlogopite	in large plates
		wernerite	
260	¾m. n.w. Somerville	chondrodite	yellow grains
		spinel	rose and reddish brown
		hydrotalcite	houghite
261	3m. n. Oxbow (Yellow lake)	chondrodite	yellow grains
		orthoclase	
		amphibole	bright green pargasite
		apatite	small, transparent, green crystals
		pyroxene	
		titanite	
		zircon	
		wernerite	large, light yellowish green crystals
		phlogopite	in large sheets
		gahnite	automolite
		fluorite	
		dolomite	
		graphite	
262	near Grasse lake	pyroxene	hemihedral crystals
		wernerite	greenish

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
257	x*†.....	vein in limestone....................	calcite, pyrite..............	5, 43, 211
	xx†	"	galena, calcite..............	5, 9, 43
	xx†	"	" sphalerite..........	5, 9, 43
	x†	"	calcite..........	43
	....	"	galena, sphalerite..........	5, 43
	....	"	....	43
	....	"	galena....................	43
	....	"	....	5, 43
	....	"	calcite....................	5, 43
258	*.......	synclinal fold of Potsdam sandstone....	....	194
	x	in limestone vein....................	quartz dolomite............	43
	x	" green shale.......................	"	5, 43
	x	....	....	5, 43
259	....	in limestone and serpentine.....	chondrodite................	5, 43
	....	"	serpentine.................	43, 93, 180
	....	'	"	43
	....	....	dolomite etc..............	80
	x	....	....	43
	....	....	....	5, 43
260	x	in limestone.......................	spinel.....................	5, 43
	....	"	chondrodite................	43
	x.......	"	spinel.....................	93, 180
261	....	limestone gneiss contact.............	....	43
	xx	"	....	43
	xx	"	pyroxene, orthoclase.......	5, 43, *w*
	x.......	"	"	43, *w*
	x.......	"	wernerite, orthoclase.......	43
	....	"	"	43
	....	"	....	43
	xx	"	quartz, titanite etc........	43, *w*
	x.......	"	"	43, *w*
	....	in limestone.......................	dolomite..................	43
	....	"	"	43
	....	"	....	43
	....	"	....	43
262	xx	limestone gneiss contact............	wernerite, titanite..........	43, 159, 229
	x.......	"	pyroxene, graphite etc......	43

NO.	LOCALITY	SPECIES	DESCRIPTION
	Rossie (*continued*)		
	near Grasse lake (*continued*).........	graphite.......	fine crystals....................
		orthoclase......	luxoclase......................
		titanite........	pale red and brown crystals.......
	Webster farm..................	apatite........	large crystals..................
	"	zircon.........	....
		amphibole.....	tremolite in short crystals........
263	2m. n. Rossie......................	wernerite......	greenish.......................
		pyroxene......	large green crystals..............
		titanite........	brown crystals..................
		tourmalin......	....
		phlogopite.....	....
	Russell		
264	Buskurk farm, 1m. n.e. Russell (?)....	danburite......	abundant fine crystals...........
		datolite........	rare..........................
		wernerite......	....
		pyroxene.....	small green crystals............
		tourmalin......	black.........................
		amphibole.....	....
		phlogopite.....	....
		albite..........	....
		quartz.........	massive and crystallized.........
		calcite.........	....
265	Moore farm e. Russell...............	pyroxene......	short, greenish black crystals......
		amphibole.....	fine, white cryst's doubly termin'ed
		wernerite......	long white prismatic crystals......
		phlogopite.....	....
266	1½m. n.w. North Russell.............	pyroxene......	fine grayish green crystals........
		phlogopite.....	large sheets....................
		apatite........	crystals and massive.............
		calcite.........	pinkish massive.................
		molybdenite....	disseminated...................
		titanite........	black crystals..................
		labradorite	grayish brown massive.........

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
	xx	limestone gneiss contact.............	pyroxene, wernerite........	5, 43
	xx	"	"	5, 43
	x.	"	"	5, 43
	....	"	orthoclase.................	*w*
	....	"	titanite etc................	*w*
	....	"	....	43
263	x.......	"	pyroxene..................	43
	x.......	"	orthoclase, apatite.........	43, 159
	x.......	"	"	5, 43
	x.......	"	"	43
	x.......	"	"	*a*
264	xx	cavities and seams in gneiss..........	pyroxene.................	22, 43, 219
	....	"	"	43
	....	gneiss limestone contact.............	" amphibole........	43
	....	"	wernerite, danburite........	43
	....	"	quartz.....................	43
	....	"	pyroxene..................	43
	....	"	" wernerite.........	43
	....	"	" quartz............	43
	....	"	danburite.................	43
	....	"	....	43
265	xx	in gneiss..........................	wernerite, amphibole......	43, 159
	xx	"	" pyroxene.......	43
	x.......	"	pyroxene..................	43, *c*
	....	"	"	43
266	xx	gneiss limestone contact.............	calcite, titanite............	*w*
	xx	"	pyrite inclusions...........	*w*
	x.......	"	calcite....................	*w*
	....	"	apatite, pyroxene etc.......	*w*
	....	"	calcite....................	*w*
	x.......	"	pyroxene, labradorite.......	*w*
	....	....	" titanite..........	*w*

SARATOGA

NO.	LOCALITY	SPECIES	DESCRIPTION
	Greenfield		
267	1m. n.w. Highrock spring Saratoga....	chrysoberyl....	pale yellowish green crystals .....
	in Mt McGregor ridge..............	garnet.........	pink grossularite ....
		tourmalin......	black crystals ....
		muscovite	reddish brown crystals..........
		orthoclase	transparent adularia ....
		apatite........	reddish brown crystals..........
		graphite	....

SCHENECTADY

The rocks of this county afford no recorded mineral

SCHOHARIE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Carlisle		
268	2m. w. Central Bridge	calcite.........	crystallized and fibrous..........
		barite.........	fibrous ....
	Esperance		
269	Ball's cave 4m. n. of Schoharie	calcite	crystals and stalactites ....
	Middleburg		
270	4m. w. Schoharie on b'k small stream..	"	geodes lined with crystals........
271	1½m. e. of Middleburg...............	"	obtuse rhombohedrons..........
	Schoharie		
272	Schoharie e. of courthouse...........	strontianite....	columnar and granular masses ...
		celestite.......	fibrous, blue ....
		barite.........	" calcareous..............
273	2m. n.e. Schoharie.................	strontianite....	crystals in geodes..............
		barite.........	massive ....
		calcite.........	" ....
274	3m. n.e. Schoharie, near Foxes creek ..	aragonite......	radiating crystals ....
275	1m. w. of Schoharie	pyrite.........	single and twinned crystals.......
		barite	fibrous ....
276	Howes Cave	calcite.........	crystals and stalactites ....
		aragonite......	slender radiating crystals ....
		pyrite.........	nodular aggregates ....
	Sharon		
277	Sharon Springs	calcite	calcareous tufa................

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
267	xx.	in granite, traversing gneiss	quartz, tourmalin, garnet...	5, 43, 210
	xx	"	" " mica	5, 43, 210
	xx	"	" garnet etc..........	5, 43, 210
	x	"	chrysoberyl...............	5, 43, 210
	x	"	" tourmalin......	5, 43, 210
	....	"	graphite..................	5, 43
	....	....	apatite..................	43

COUNTY

localities of sufficient importance to note in this list

COUNTY

268	....	in Helderberg limestone	barite....................	43
	....	"	calcite....................	43
269	....	in hydraulic limestone...............	....	5, 43
270	....	in limestone.......................	....	5
271	....	" veins in limestone	....	5
272	xx	thin veins in hydraulic limestone......	barite, calcite	5,43,63,177
	....	"	strontianite calcite.........	5. 43. 63
	....	"	....	43, 63
273	....	in hydraulic limestone...............	barite, calcite..............	43, 63, 177
	....	"	strontianite calcite.........	43, 63
	....	"	pyrite....................	43, 63
274	x	"	....	63
275	xx	in blue slate.......................	....	5, 43, 63
	....	vein in blue slate..................	....	63
276	x.......	in hydraulic limestone..............	....	5, 43
	....	"	calcite....................	*h*
	....	in shale...........................	....	*w*
277	....	in limestone near springs............	....	5

SCHUYLER

The rocks of this county afford no recorded mineral

SENECA

The rocks of this county afford no recorded mineral

STEUBEN

The rocks of this county afford no recorded mineral

SUFFOLK

The surface rocks of this county consist of glacial drift and afford

SULLIVAN

NO.	LOCALITY	SPECIES	DESCRIPTION
	Mamakating		
278	Wurtzboro, lead mine	galena	mainly massive
		sphalerite	
		chalcopyrite	
		pyrite	

TIOGA

The rocks of this county afford no recorded mineral

TOMPKINS

The rocks of this county afford no recorded mineral

ULSTER

NO.	LOCALITY	SPECIES	DESCRIPTION
	Kingston		
279	Rondout, cement mines	calcite	flat rhombohedrons, pyrite inclusions
		quartz	crystals showing phantom of smoky quartz
		pyrite	cubic
		marcasite	small crystals
	Marbletown		
280	High Falls	pyrite	pyritohedral crystals
	Wawarsing		
281	Ellenville, lead mine	galena	crystals rare
		chalcopyrite	" well modified
		quartz	in groups and isolated crystals
		sphalerite	massive black
		brookite	small, brilliant crystals
		pyrite	

COUNTY

localities of sufficient importance to note in this list.

COUNTY

localities of sufficient importance to note in this list.

COUNTY

localities of sufficient importance to note in this list.

COUNTY

no mineral localities of sufficient importance to note in this list.

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
278	*†	in quartzite	sphalerite, chalcoypyrite	5, 43
		"	galena	5, 43
		"	" sphalerite	5, 43
		"	" "	5, 43

COUNTY

localities of sufficient importance to note in this list.

COUNTY

localities of sufficient importance to note in this list.

COUNTY

279	x	in Helderberg limestone	quartz	*h, p*
	xx	"	calcite	*p*
		"	"	*p*
	x	"	"	*h, w*
280		in Helderberg limestone		5
281	*	vein in quartzite	chalcopyrite, sphalerite	5, 43
	xx	"	quartz "	5, 43
	xx	"	chalcopyrite	5, 43
		"	galena, chalcopyrite	5, 43
	x	"	quartz	43
		"	chalcopyrite	43

WARREN

NO.	LOCALITY	SPECIES	DESCRIPTION
	Caldwell		
282	Diamond island, Lake George........	quartz.........	similar to Herkimer county.......
		calcite.........	white to yellow nail head crystals..
		dolomite.......	....
	Chester		
283	e. Loon lake........................	pyrite.........	crystallized....................
		chalcopyrite....	imperfect crystals..............
		rutile..........	....
		tourmalin......	....
	Hague		
284	Sabbath Day Point................	epidote........	common massive...............
		wernerite......	....
		titanite........	....
285	Graphite 4m. w. Hague.............	graphite.......	leafy masses..................
		apatite........	small crystals..................
		garnet.........	large red crystals..............
	Johnsburg		
286	Moore's mine, Gore mountain.........	garnet.........	massive......................
		pyroxene......	coccolite.....................
287	North River Garnet Co.'s m., Oven mt.	garnet..........	massive......................
		pyroxene......	coccolite.....................
	Queensbury		
288	Glens Falls.........................	calcite.........	crystals of lenticular form........
		dolomite.......	well defined crystals............
	Thurman		
289	Thurman..........................	fluorite........	....
		zircon.........	large and interesting crystals.....
		graphite.......	irregular shaped masses.........
		serpentine.....	yellowish green................
		pyrite.........	fine crystals..................
		garnet.........	almondite....................
	Warrensburg		
290	Warrensburg iron mine.............	magnetite.....	....

WASHINGTON

NO.	LOCALITY	SPECIES	DESCRIPTION
	Fort Ann		
291	1m. n. Fort Ann....................	graphite.......	....
		pyroxene......	....
		quartz.........	....
292	Shelving Rock.....................	serpentine.....	yellowish green, translucent......

COUNTY

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
282	x.......	Beekmantown limestone.............	calcite....................	5, 43
	x.......	"	quartz....................	43
	....	"	"	5
283	x.......	crystalline limestone.................	tourmalin, rutile...........	5, 43
	....	"	"	43
	....	"	....	5, 43
	....	"	....	5, 43
284	....	in gneiss..........................	....	5
	....	"	titanite..................	*f*
	....	"	wernerite.................	*f*
285	*.......	quartzite and limestone..............	quartz....................	111
	....	"	zircon....................	111
	....	in gneiss..........................	sillimanite	111
286	*.......	in hornblende schist................	pyroxene..................	112, *e*
	....	"	garnet....................	*w*
287	*.......	"	pyroxene..................	112, *e*
	....	"	garnet....................	*w*
288	....	in Trenton limestone.................	dolomite..................	5
	....	"	calcite....................	5, 43
289	xx......	crystalline limestone................	pyrite etc.................	5, 43
	xx......	in quartz vein......................	graphite..................	5, 9, 43
	x.......	"	zircon, garnet	5
	x.......	crystalline limestone................	....	5, 43, 132
	x.......	"	....	5, 43
	....	in quartz vein	....	*e*
290	*†......	....	....	194

COUNTY

291	x	gneiss limestone contact.............	pyroxene, quartz...........	5, 43
	....	"	quartz....................	5
	....	"	graphite..................	5
292	x	crystalline limestone................	....	5

WASHINGTON

NO.	LOCALITY	SPECIES	DESCRIPTION
	Granville		
293	....	pyroxene......	lamellar......................
		orthoclase......	massive......................
		epidote........	....
294	Middle Granville....................	pyrolusite......	dendrites.....................
	Putnam		
295	Anthony's Nose....................	hematite.......	mammillary, botryoidal..........

WAYNE

NO.	LOCALITY	SPECIES	DESCRIPTION
	Wolcott		
296	Wolcott mine......................	hematite.......	fossil ore......................
		barite.........	pinkish crystals, highly modified..
297	Ontario mines.....................	hematite.......	oolitic ore.....................

WESTCHESTER

NO.	LOCALITY	SPECIES	DESCRIPTION
	Cortlandt		
298	Anthony's nose 4m. n.w. Peekskill on northern side of mountain..........	pyrrhotite......	massive......................
		chalcopyrite....	" ....
		magnetite......	sparingly disseminated...........
		pyroxene......	....
		amphibole.....	....
		apatite........	small green crystals.............
		calcite.........	tabular crystals coated with quartz
299	Crugers...........................	pyroxene......	white.......................
		amphibole.....	....
		staurolite......	minute crystals................
		cyanite........	....
		sillimanite.....	fibrolite......................
300	emery mines between Crugers and Peekskill.......................	corundum.....	emery, intimately mixed with magnetite..................
		magnetite......	intimately mixed with emery.....
		spinel.........	hercynite.....................
		garnet.........	small rounded crystals...........
301	south side of Verplanck Point........	chrysolite......	....
		garnet.........	....
		staurolite......	....
		amphibole.....	gray green actinolite............
		pyroxene......	....

COUNTY *(continued)*

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
293	x		orthoclase, epidote	43
				43
				43
294		in Georgia quartzite and slates		43
295		in gneiss		27, 111

COUNTY

296	*†	Clinton formation		194
		"	hematite	43
297	*	"		194

COUNTY

298	*†	in gneiss	chalcopyrite	5, 43, 101
		"	pyrrhotite	43, 101
		"	"	43
		"	amphibole, calcite	43
		"	pyroxene	43
		"	chalcopyrite	43, *e*
	x	"		43
299		in norite contact	amphibole	43, 228
		"	pyroxene	43
		"	sillimanite	43, 228
		"	"	228
		"	staurolite	43, 228
300	*	in norite	spinel garnet	43, 228
	*	"	"	43, 228
		"	magnetite	43
		"	"	228, *w*
301		in norite contact		44
		" mica schist	staurolite	44
		"	garnet	44
		in limestone	pyroxene	44, 228
		"	amphibole	228

WESTCHESTER

NO.	LOCALITY	SPECIES	DESCRIPTION
	Cortlandt (*continued*)		
302	Peekskill	amphibole	
		staurolite	small crystals
		graphite	
	Eastchester		
303	Tuckahoe	dolomite	massive
		phlogopite	
		sphalerite	dark rounded masses
		pyrite	
		chalcopyrite	
	Harrison		
304	1m. w. Port Chester	serpentine	pinkish brown masses
		brucite	
		chlorite	
		tourmalin	black
		amphibole	tremolite
	Mt Pleasant		
305	Pleasantville	muscovite	large sheets, magnetite inclusions
	New Rochelle		
306	New Rochelle, Davenport's neck	serpentine	yellow, green and pinkish
		magnesite	snow white crusts
		brucite	small, imperfect crystals
		amphibole	actinolite, tremolite and hornblende
		enstatite	bronzite
		chromite	disseminated crystals and grains
		quartz	drusy crystals and chalcedony
		garnet	small, imperfect crystals
		titanite	
		deweylite	
		calcite	crystalline massive
	Ossining		
307	Ossining, Prison quarry	pyroxene	malacolite
		amphibole	tremolite
		pyrite	small bright crystals
		graphite	crystals

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
302	....	in norite........	....	43
	....	in mica schist........	....	43, 223
	....	"	....	43
303	*.......	dolomitic limestone........	pyrite, chalcopyrite........	5, 43
	....	"	....	*m*
	....	"	pyrite, chalcopyrite........	43
	....	"	dolomite........	43
	....	"	"	43
304	....	mica schist........	brucite etc........	5, 43
	....	in serpentine........	serpentine........	*m*
	....	"	amphibole........	5, 43
	....	in mica schist........	....	5, 43
	....	" serpentine........	brucite etc........	5, 43
305	x	....	....	*e*
306	....	neighboring rock mica schist........	brucite, chromite........	5, 43, 129
	....	on serpentine........	serpentine, brucite........	5, 43
	....	"	" etc........	5, 43
	....	serpentine........	enstatite, garnet........	5, 43, 129
	....	"	amphibole........	43, 129
	....	"	serpentine........	5, 43
	....	vein in serpentine........	deweylite........	5, 43, 129
	....	in mica schist and hornblende rock....	titanite........	5, 43
	....	"	garnet........	43
	....	vein in serpentine........	chalcedony........	129
	....	"	"	129
307	x.......	in dolomitic limestone........	amphibole........	5, 43
	x.......	"	pyroxene, pyrite........	43
	x.......	"	amphibole........	43
	x.......	"	calcite........	*e*

WESTCHESTER

NO.	LOCALITY	SPECIES	DESCRIPTION
	Ossining (*continued*)		
	Ossining, Prison quarry (*continued*)...	quartz	chalcedony incrusting dolomite crystals.....................
		"	crystals, occasionally doubly terminated....................
		dolomite.......	crystals ....
		talc	green foliated ....
		rutile..........	slender prismatic crystals........
		serpentine	pseudomorph after pyroxene .....
		calcite.	scalenohedral crystals...........
308	Sparta, 1m.s. Ossining (old copper mine)	cerussite.......	small prismatic crystals..........
		pyromorphite ..	mammillary incrustations on galena........................
		anglesite......	....
		vauquelinite...	green and brownish concretions...
		wulfenite......	sparingly in tabular crystals .....
		vanadinite	....
		galena.........	....
		chalcopyrite ...	in minute crystals and massive ...
		azurite........	....
		malachite......	....
		pyrite.........	small crystals ....
		calcite.........	crystals of prismatic habit ....
309	Shafts 3 and 4 New Croton aqueduct 4m. s.e. Croton Landing...........	stilbite.........	radiated aggregates.............
310	Shaft 5 New Croton aqueduct, Whitson	rutile..........	....
		harmotome.....	twin crystals lining vugs.........
		heulandite.....	....
		stilbite........	small, sheaflike aggregates.......
		pectolite.......	....
		beryl..........	....
		pyrite.........	small bright crystals............
		barite.........	white crystals and masses........
		quartz.........	rough, imperfect crystals.........
		calcite.........	modified crystals, P't Henry type
		chrysolite......	yellow grains..................
		tourmalin......	minute, transparent, yellow prisms

COUNTY *(continued)*

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
	x......	in dolomitic limestone...............	dolomite..................	*e*
	xx......	"	"	*e*
	....	"	talc, mica.................	*e*
	....	"	dolomite..................	*e*
	....	"	" quartz............	*e*
	xx.....	"	pyrite.....................	*c*
	x.......	"	dolomite..................	*e*
308	....	"	galena, chalcopyrite	5, 43
	....	in dolomitic limestone...............	galena, chalcopyrite	5, 43
	....	"	....	43
	....	"	pyromorphite	5, 43
	....	"	vanadinite, pyromorphite...	43
	....	"	wulfenite..................	43
	....	"	chalcopyrite, cerussite......	43
	....	"	galena....................	5, 43
	....	"	malachite, galena...........	5, 43
	....	"	azurite, galena	5, 43
	....	in gneiss.........................	calcite....................	*e*
	....	on mica schist.....................	....	*e*
309	....	on gneiss.........................	calcite, pyrite.............	*e*
310	....	in "	....	43, *e*
	xx......	"	pyrite, barite..............	43, *e*
	x.......	"	"	43
	....	"	....	43, *e*
	....	"	....	43
	....	"	....	5, 43
	....	"	calcite....................	*e*
	....	"	"	*e*
	....	"	"	*e*
	....	"	pyrite.....................	*e*
	....	"	prochlorite, tourmalin......	*e*
	....	"	" chrysolite......	*e*

WESTCHESTER

NO.	LOCALITY	SPECIES	DESCRIPTION
	Yonkers		
311	2½m. n. Yonkers on aqueduct	pyrite	
		calcite	
		amphibole	tremolite in radiated aggregates
		garnet	small, rounded crystals & masses
		tourmalin	black crystals seldom perfect
		stilbite	
		muscovite	rhombic prisms
		apatite	transparent crystals
		epidote	massive and crystals
		analcite	small, perfect crystals
	Yorktown		
312	Croton Lake	sillimanite	fibrolite
		monazite	good crystals

WYOMING

Salt is obtained in commercial quan-

YATES

The rocks of this county afford no recorded mineral

COUNTY (*continued*)

NO.	QUALITY	GEOLOGIC ASSOCIATION	MINERALOGIC ASSOCIATION	AUTHORITY
311	x	in gneiss		43
		"	amphibole	43
		"	calcite, muscovite	5, 43
		"	tourmalin	5, 43
		"	apatite, garnet	5, 43
		"	calcite	5
		"	amphibole	5, 43
		"	epidote	5, 43, 115
		"	apatite	115
		"	tourmalin etc	5, 43
312		in mica schist	monazite, amphibole	43
		"	sillimanite	43

COUNTY

tities from the rocks of this county.

COUNTY

localities of sufficient importance to note in this list.

CORRELATION LIST ARRANGED ACCORDING TO SPECIES

The numbers refer to the numbered localities given in columns 1 and 5 of the preceding list.

Albite, 23, 61, 63, 126, 128, 210, 246, 253, 264.
Allanite, 55, 169.
Amphibole, 13, 34, 37, 52, 55, 59, 72, 86, 99, 101, 104, 120, 140, 141, 142, 143, 147, 148, 166, 167, 168, 169, 171, 172, 175, 177, 178, 179, 180, 185, 186, 187, 190, 191, 194, 195, 198, 202, 203, 204, 206, 207, 209, 210, 217, 220, 222, 226, 227, 229, 230, 236, 237, 240, 241, 242, 246, 252, 256, 261, 262, 264, 265, 298, 299, 301, 302, 304, 306, 307, 311.
Analcite, 311.
Anglesite, 257, 308.
Anhydrite, 150, 213.
Ankerite, 78, 88.
Anthracite, 42, 109.
Apatite, 20, 46, 55, 67, 68, 100, 104, 148, 181, 196, 198, 210, 230, 236, 239, 241, 246, 261, 262, 266, 267, 285, 298, 311.
Apophyllite, 130, 210, 218.
Aragonite, 6, 213, 259, 274, 276.
Arsenopyrite, 52, 184, 193, 203.
Autunite, 136.
Azurite, 308.
Barite, 76, 77, 85, 89, 94, 108, 110, 162, 221, 227, 228, 234, 240, 241, 248, 258, 268, 272, 273, 275, 296, 310.
Beryl, 87, 116, 119, 135, 310.
Biotite, 171, 172, 175, 177, 210, 240, 256.
Brookite, 281.
Brucite, 210, 213, 304, 306.
Cacoxenite, 69.
Calcite, 1, 2, 5, 6, 9, 11, 13, 18, 30, 46, 60, 66, 67, 68, 70, 74, 75, 78, 79, 89, 90, 93, 99, 103, 104, 107, 108, 110, 116, 149, 150, 151, 153, 159, 167, 172, 204, 208, 210, 218, 221, 223, 225, 227, 231, 244, 249, 255, 257, 264, 266, 268, 269, 270, 271, 273, 276, 277, 279, 282, 288, 298, 306, 307, 308, 310, 311.
Celestite, 9, 84, 86, 93, 95, 96, 99, 108, 150, 154, 162, 257, 272.
Cerussite, 257, 308.
Chabazite, 128, 148, 218.
Chalcocite, 26, 27, 39.
Chalcopyrite, 22, 27, 33, 39, 46, 82, 90, 100, 149, 223, 257, 278, 281, 283, 298, 303, 308.
Chlorite, 46, 304.
Chondrodite, 66, 166, 175, 177, 178, 180, 184, 187, 198, 210, 260, 261.
Chromite, 172, 208, 213, 306.
Chrysoberyl, 267.
Chrysolite, 220, 301, 310.
Clinochlore, 144, 178, 210.
Clinohumite, 210.
Corundum, 178, 179, 300.
Cuprite, 216.
Cyanite, 118, 139, 299.
Danburite, 264.
Datolite, 127, 210, 218, 224, 264.
Deweylite, 213, 306.
Dimagnetite, 171.
Dolomite, 6, 11, 30, 34, 77, 79, 108, 110, 115, 143, 150, 151, 204, 206, 210, 213, 259, 261, 282, 288, 303, 307.
Dumortierite, 132, 136.
Enstatite, 180, 210, 229, 306.
Epidote, 46, 114, 128, 133, 140, 148, 166, 169, 174, 182, 194, 199, 200, 205, 210, 222, 284, 293, 311.
Epsomite, 2, 9, 30, 149.
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Appendix 3

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New York State Museum

Bulletin 80

PALEONTOLOGY 10

REPORT OF THE STATE PALEONTOLOGIST 1903

Plate 1

Fossil trails on Potsdam sandstone, Bidwell's Crossing, Clinton co. Taking out the slab in sections [*see* p. 18]

University of the State of New York

New York State Museum

JOHN M. CLARKE State Paleontologist

Bulletin 80

PALEONTOLOGY 10

REPORT OF THE STATE PALEONTOLOGIST 1903

To the Regents of the University of the State of New York

I have the honor to report herewith on the work of this department during the year commencing Oct. 1, 1902.

Operations in the field 1902-3

Stratigraphic survey of the Schoharie region. The earliest stratigraphic determinations in New York based on a careful collation of paleontologic evidence were made in the valley of the Schoharie creek and the region immediately about Schoharie Court House by two generations of the Gebhard family. The formations along the creek south of Esperance are exposed to extraordinary advantage and their richness in organic remains, combined with the eager zeal for the study of nature possessed by the Gebhards, father and son, led to the appointment of John Gebhard jr as assistant on the original geological survey because of his familiarity with the geology and the contents of the rocks in this portion of the first district, then assigned to the charge of Lieutenant Mather. The outcome of this early study of the rocks in the Schoharie valley has made itself effective in the paleontology of New York in many ways. When Professor Hall came to study the paleontology of the formations there represented, he found it imperative for him to rely chiefly for his subject-matter on the extraordinarily fine and complete Gebhard collections. The account given by him of the species of the Lower Helderberg and Oriskany faunas, which constitutes volume 3 of the *Palaeontology of New York,* was so largely derived from these collections that it was deemed wise by the museum to

subsequently acquire one of them, and on a later occasion still another was secured from the same source. Because of these facts the Schoharie section has become a basis of reference in studying these faunas, and for 50 years past it has been a region freely visited by students of geology; and yet during all this time no geologic map of the area has been published except on a very small scale in conjunction with and as a part of the maps of the State as a whole. To meet a definite want on the part of students, and for the more detailed exposition of the geology of that region a map has been completed during the present season on the quadrangle scale which covers the area from Middleburg northward to the south line of Montgomery county. The work has been carried out by Prof. A. W. Grabau, who has previously labored with much credit on similar problems, and his map and report thereupon are presented in the following pages.

Structure of the disturbed fossiliferous rocks in the cement district about Rondout. The lucid and very interesting exposition of the geology of Becraft mountain which was given in my last report has led to a consideration of the rather more complicated region of rocks of like age on the opposite or west side of the Hudson river. Becraft mountain in Columbia county is the remotest outlier of the series of rock beds which so extensively enter into the composition of the Helderberg mountains of Albany county. At Kingston, Hudson and eastward these rocks were caught in the Appalachian folding, and subsequent erosion of these folds has isolated the area at Becraft mountain entirely from the parent mass. At Rondout and vicinity the rocks have been left in continuity, but it has long been recognized that they are exposed under much perplexity of form, due to the folding and displacement of the beds. The structural problems presented there have never been understood and as long as geologic work has been carried on in this State the situation in this region has been somewhat timorously approached. These problems seemed to afford features of much interest connected with the tectonics of the region and the mode of the Appalachian disturbances, and the fact was recognized that a solution would probably not be found

without the aid of the evidence derived from studying the fossils. I therefore asked Mr Gilbert van Ingen, who at that time was officially connected with this department and who had many years' familiarity with the region, to undertake the attack on the difficult situation there presented. Mr van Ingen with the assistance and cooperation of Mr P. Edwin Clark, for many years superintendent of the Newark Lime & Cement Co. at Rondout and mining engineer of long experience, has given the subject very detailed examination and careful study. His results were presented in the report of last year and will be found to afford a well illustrated exposition of the obscure and complicated structure of the region.

Traverses of the Catskill mountains and collections of the fauna of the Port Ewen beds. During a part of the season Mr George H. Chadwick has been engaged in reviewing the section of the Catskill mountains in Greene county, in the hope of ascertaining some new clues to the nature of the life forms in the higher strata. Subsequently he was occupied in collecting as freely as practicable from the limestone and shale beds which constitute the Port Ewen (formerly termed the Kingston) beds and best exposed in the vicinity of Rondout and Kingston. This formation is that at the top of the series originally termed the Helderberg and subsequently Lower Helderberg, and is a sedimentary facies reproducing that of the Catskill shaly limestone below, otherwise known as the New Scotland beds. The fauna of these upper beds has not been carefully analyzed, though there has been a well grounded belief that its affinities were with the later or Oriskany fauna rather than with that of the Helderbergian beneath.

Distribution of the Cobleskill limestone. Reference was made in the last report to the study of this formation, the importance of which as an element in the New York series had not heretofore been recognized. Mr C. A. Hartnagel has continued and concluded this study and has traced the formation from Port Jervis at the south, northward through Orange and Ulster counties and from Schoharie county westward through Otsego,

Herkimer and Onondaga counties and on to Erie county. The outcome of Mr Hartnagel's work has been to demonstrate the continuity of this apparently feeble element in the rock succession and to indicate its significance as a closing phase of the Siluric formation and fauna in the State of New York. Originally brought into the nomenclature of the science as the Coralline limestone and believed to have a purely local significance in the Helderberg region and the adjoining districts westward, it is now found to have been notably underestimated in its continuity and extent.

Paleontology and stratigraphy of the slate belt of eastern New York. Mr Ruedemann, who has been concerned with the problems presented by the obscure and somewhat complicated structure of this region, has continued his investigations, giving special attention to the region about Granville, for the purpose of reexamining the localities from which Messrs Walcott, Dale and Prindle obtained paleontologic evidence during their study of the region. The exploitation of the graptolite faunas of these rocks, which here, as in other parts of the world, have been found of material importance for the correlation of these with distant formations, has led to the restudy of the structure of Mt Moreno near Hudson which, previously known by an excellent exposure of the Normanskill graptolite shale, has become still more interesting by the discovery of the uppermost zone of the Phyllograptus shale before known in New York only from the Deep kill section of Rensselaer county. All the data now obtainable bearing on the composition of these graptolite zones and the correlation of these geologic formations with those of remote regions of the world have been brought together in the form of a monograph of the graptolites of the older New York rocks, and this is now in press.

Beekmantown and Chazy formations of the Lake Champlain basin. In continuing an examination of the lower faunas of this region, which has been carried on during several seasons, the assistant paleontologist spent the greater part of the field season. The real import of these faunas in the paleontology of New York

was not brought out in the early surveys of the region, and we owe our present knowledge of them, specially of the former, chiefly to the labors of Professors Brainerd and Seely of Middlebury Vt., whose investigations however were chiefly confined to Vermont, and to Professor Whitfield, who has described most of the fauna as now known. The congeries of life forms herein is surprisingly profuse and embodies a multitude of novel species of notable interest. It was deemed necessary for a successful exploitation of these two formations to determine the detailed succession of the faunas bed by bed at the typical exposures, Beekmantown and Chazy. Thereafter the exposures on Valcour island, which are of unusual interest, were examined in detail, specially the cliffs along the west and south shores. A large amount of material was acquired by this work, and some account of the new forms obtained is appended to this report. A fuller revision and description of the entire faunas of the Beekmantown and Chazy formations will be undertaken when the other exposures in this region have been carefully examined.

Correlation of the New York Devonic with that of Gaspé, Canada. In a previous report record was made of the effort to elucidate the composition and origin of the early Devonic faunas of New York by a comparative study of the Devonic areas in the eastern counties of the Province of Quebec. Here the faunas attained unexampled profusion of development and it was shown as a result of a brief collecting trip to Grande Grève, Quebec and Dalhousie N. B., by the paleontologist in 1900, that a close examination of the fauna of the Grande Grève limestones would bring out many facts helpful to the problems before us in New York. The Grande Grève limestones exposed on the north shore of Gaspé bay are repeated only at Percé, on the westernmost coast of Gaspé county, south of Gaspé bay, and this spot was visited during the past summer. The environs of the fishing village of Percé are of extraordinary interest to the student of the older rocks. The limestone series has been greatly disturbed here, the faulting having brought up sections of those rocks in different places and at differing angles. Only the Percé rock, a stupen-

dous detached cliff cut off by the action of the sea from the mainland, satisfactorily represents that portion of the limestone series to which in northern Gaspé the term *Grande Grève limestones* has been applied. This mass of reddish and yellowish limestones rising from the sea with sheer walls and vertical strata is profuse in interesting fossils, of which a large number were obtained, together with interesting series from the limestone exposures of earlier age. It is safe to say that the collections in the possession of the State Museum, both of the fossils at Percé and of those at Grande Grève, are without equal. In a subsequent part of this report I have added a brief preliminary account of the stratigraphy and paleontology of Percé.

Areal survey of the Elmira, Watkins, Ithaca and Waverly quadrangles. As reported last year operations were carried on during the season of 1902 in cooperation with the United States Geological Survey in an areal survey of the Elmira quadrangle. Under this arrangement as carried into practice in the Olean and Salamanca quadrangles stratigraphers were furnished for the field work from the corps of the survey and their expenses were met from the appropriations of this department, and we undertook at the same time to acquire the necessary paleontologic collections for proving the stratigraphic work. The stratigraphic work on the Olean and Salamanca sheets was chiefly done by Prof. L. C. Glenn, a skilful and exact observer, and the paleontologic collections therein were acquired and largely determined by Mr Charles Butts, representing this department. In my judgment the work of these two men was carefully executed, though leading to some divergence of conclusion with regard to classification.

The basis of this cooperation conceded to us the use for our publications of such maps and reports as the geologists of the United States Geological Survey should prepare, but we have found it impracticable to avail ourselves of this provision, first, for the reason that the scale of the United States Geological Survey folio maps is one we regard unsuited to our practice and, again, that the execution of these maps and reports was to

be so long deferred as to qualify their usefulness to us. We were therefore compelled to incur the unexpected expense of engraving these maps on the quadrangle scale and to have a special report prepared to accompany them. In the work on the Elmira quadrangle, it was my desire and plan to cover continuously therefrom in this areal survey the adjoining territory to the north and east, as therein were involved some interesting questions of classification of the rocks and faunas concerning which we had been diligently acquiring data for many years. The outcome of that work in 1902 was disappointing. No data were acquired by the stratigraphers on which even a preliminary areal map could be constructed and I was unable that year to send our more experienced workers into this rather difficult field to check up the determinations of the stratigraphers. In consequence therefore we decided to hereafter execute such work ourselves. It is hardly to be expected that geologists whose experience has been restricted to broad reconnaissance in imperfectly known regions can enter anywhere in this State where the rocks have been continuously studied for nearly 70 years and achieve the results required in New York. It is not our desire to encourage such enterprises. We have therefore made a new start this season beginning with the Elmira quadrangle and extending the work in detail north to the Watkins quadrangle. The undertaking has been essentially in charge of D. D. Luther, whose skill in the careful stratigraphic determination of the older rocks in New York is in my judgment not to be surpassed. This work has occupied essentially all of Mr Luther's time, with that of H. S. Mattimore, during the field season of 1903, with the result that the Elmira and Watkins maps are essentially complete and the Ithaca and Waverly sheets fairly covered.

Office work

Publications

During the past year the following publications have been issued by the department.

Memoir 5. Guelph Fauna in the State of New York. Q. 196p. 21 litho. pl. This is an exposition of a virtually new or heretofore un-

recognized element in the New York faunas. It contains chapters as follows:

Memoir 6. Naples Fauna in Western New York, part 2. The first part of this treatise, which considered only the cephalopods of the fauna appeared in the *16th Annual Report of the State Geologist 1896* [1899]. It covered 169 pages and 9 plates, royal quarto. The present memoir is a completion of the subject, covering 215 pages and 21 plates. It includes chapters as follows:

Bulletin 65. *Type Specimens of Paleozoic Fossils in the New York State Museum.* This catalogue, which has been an arduous compilation and long in press, is a record of the possessions of the museum in this important class of objects. Type specimens of natural objects, that is the actual material on which published descriptive accounts and discussions have been based, constitute the unique treasures of a museum. Such objects once lost or destroyed, replacement is impossible. Howsoever imperfect or fragmentary the type or original specimen may be, of however superior quality some other example of the same creature, the second can not serve to scientific students the function of the first. The type specimen is the basis of comparison and reference for all time.

The publication of the *Palaeontology of New York* and the extensive list of papers accessory and supplementary thereto have given birth to a very large number of type specimens from the paleozoic strata of America. Some part of these, specially that utilized in the early volumes of the paleontologic reports, was the personal property of the author of those reports and passed from his hands to the possession of the American Museum of Natural History in the city of New York. Till the preparation of this catalogue was begun, no serious effort to bring together the type specimens in the State Museum of these and other descriptions into one place or record was ever carried to completion. Some years ago the writer undertook the work of publishing lists, believed to be complete at the time, of certain of the organic groups, namely the Crustacea, Vermes and Cephalopoda;[1] but a revision of these lists has shown considerable omissions, due somewhat to normal growth as investigations have progressed but more to the fact that these types have been scattered all through the collections of the museum both in the State Hall and in Geological Hall. It has been an arduous task to search out and bring together these specimens, which during the past half century have become so widely and carelessly diffused, but their number is noteworthy, and the importance of this record justifies the labor put on it.

[1] N. Y. State Geol. 11th An. Rep't. 1892. p.31–53; 12th An. Rep't. 1893. p.57–104.

This catalogue is arranged as follows:

The general classification is biologic and follows the broadest subdivisions. Each entry represents a single specimen and is accompanied by two numbers, the first serial, the second fractional and corresponding to the number borne by the specimen. In this fractional number the numerator carries the number assigned to the major division, the genus and the species, while the denominator indicates the number of the specimen of the species. Thus, the sponge *Dictyospongia sceptrum* Hall (sp.) carries the number $\frac{2264}{2}$. 2000 is the number assigned to the Spongiae, 2260 that assigned to the genus Dictyospongia, 2264 the number for D. *sceptrum*, the fourth species of that genus, and $\frac{2264}{2}$ the number for the second specimen of this species. In the scheme of numbering the following is the allotment made for the major biologic divisions.

Plantae	100	Lamellibranchiata	9 000
Protozoa	1 000	Gastropoda	10 000
Spongiae	2 000	Pteropoda	11 000
Cnidaria	3 000	Cephalopoda	12 000
Echinodermata	4 000	Crustacea	13 000
Vermes	5 000		14 000
Bryozoa	6 000	Tracheata	15 000
Brachiopoda	7 000	Pisces	16 000
	8 000		

For ease of use it has been the purpose to keep these divisions as broad as practicable, in order to avoid duplicating too often the alphabetic arrangement of the species and to maintain the elasticity of the scheme in the incorporation of future additions. The work does not purport to be one on taxonomy, but aims to present the arrangement in the simplest form. During the progress of the printing of the catalogue, a period of 18 months, the continuous publication of paleontologic researches and acquisitions to the collections by gift and purchase have notably increased the number of type specimens and these have been added in a supplementary list brought up to February 1903.

While the main part of the book is devoted to the biologic arrangement of the type material, a second part gives a concise relisting of the species in their stratigraphic arrangement.

A chief purpose of this record is to make available to students the card catalogue of these types now in the possession of the museum. At the same time it serves to indicate the wealth of the museum in these important elements, of which upward of 5000 are here listed, a number which exceeds all type specimens of paleozoic organisms from the New York rocks in the possession of all other collections taken together.

This list of type specimens was complete up to the time of going to press, but the progress in our work since then has already necessitated the preparation of a second supplementary list including the increase to the present time, and such list is submitted as a part of this report. These accessions to our collection of type specimens now raise the total to 5700.

Bulletin 66. The Ellis *Index to Publications of the New York State Natural History Survey and New York State Museum.* This admirable compilation is entitled to special notice here, because of its exhaustive treatment of the paleontologic publications and its index to descriptions of genera and species of fossils. The latter part of the book covering 127 pages was prepared in this office. It has reference solely to dates of publication and undertakes no notice of subsequent revision of generic or specific names. It contains upward of 5000 references.

Bulletin 69. Report of the State Paleontologist for 1902. This bulletin contains the following scientific papers:

Dwarf Fauna of the Pyrite Layer at the Horizon of the Tully Limestone in Western New York. 5 litho. pl. By F. B. Loomis

Mastodons of New York. 3 pl. By John M. Clarke

Cambric Dictyonema Fauna in the Slate Belt of Eastern New York. 5 pl. By Rudolf Ruedemann

Sedentary Impression of the Animal whose Trail is Known as Climactichnites. 2 pl. By Jay B. Woodworth

Devonic and Carbonic Formations of Southwestern New York. 2 pl. 1 map. By L. C. Glenn

Fossil Faunas of the Olean Quadrangle. By Charles Butts

Construction of the Olean Rock Section. By John M. Clarke

Stratigraphy of Portage Formation between the Genesee Valley and Lake Erie. 1 map. By D. Dana Luther

Stratigraphy of Becraft Mountain, Columbia County, N. Y. 1 map, 2 sections. By Amadeus W. Grabau

A New Eurypterid Fauna from the Base of the Salina of Western New York. 21 litho. pl. By Clifton J. Sarle

Preliminary Observations on the Cobleskill (Coralline) limestone of New York. 2 pl. 1 map. By C. A. Hartnagel

Disturbed Fossiliferous Rocks in the Vicinity of Rondout N. Y. 13 pl. By Gilbert van Ingen and P. Edwin Clark

Torsion of the Lamellibranch Shell. 1 pl. By John M. Clarke

Some Devonic forms. 2 litho. By John M. Clarke

The labor necessary to preparing the publications above listed has been an essential part of the office duties of all members of the staff. We look on the outcome of the year in this regard as fruitful and satisfactory but as in nowise lessening the sum of the problems still before us.

I have added to this report a detailed discussion of the Lower Devonic rock section at Port Jervis prepared by Prof. H. W. Shimer of the Massachusetts Institute of Technology. The paper has features of special interest in the analysis of the faunas of the Port Ewen beds and the Oriskany limestone of Trilobite mountain.

Investigations in progress

Correlation study of the Helderberg, Oriskany and Grande Grève faunas. These investigations have progressed as opportunity has afforded and the work is near completion. The richness of the Grande Grève and Percé fauna in comparison with those of the New York Helderberg and Oriskany will make the faunal lists extensive, and the close analysis indicates variations due to different physical conditions, which in the fauna of a single geographic province might escape notice. The problems presented by this study are not merely those of the constitution of a fauna or certain allied faunas but rather the variations due to distribution or occurring in the dissemination of the fauna. Necessarily involved therewith is the interpretation of the paleography of the early Devonic of eastern America and incidental thereto the local geology of points both in New York and Gaspè. It is hoped to complete this work in course of the present year.

Graptolites of the slate belt of eastern New York. This series of investigations on the nature of the graptolite faunas of New York and their correlation with those of other parts of the world has been completed so far as relates to the earlier rocks. A second part of these investigations will include the later manifestations of the graptolite faunas. The graptolites have proved under the recent studies of European and American paleontologists the leading fossils for the subdivision of the Siluric deposits into zones of life and correlation. The first serious studies of their organization were made by James Hall and Ebenezer Emmons, and Professor Hall's elaborate and beautifully illustrated memoir on the *Graptolites of the Quebec Group*, 1865, republished in the 20th annual report of the State Museum as an "Introduction to the Study of the Graptolitidae" has been classical for the study of these forms. Our knowledge of these objects has however been greatly augmented by the investigations carried on by European authors, specially by Lapworth on the distribution and classification of the British graptolites. As far back as 1886 that writer indicated the general parallelism in the succession of these faunas in Canada and Great Britain, and in papers already published in our own reports the same line of inquiry and demonstration has been followed, together with contributions to their anatomy, physiology and bionomy. The present work covers with some degree of detail and in successive chapters the following subjects of inquiry: history of the study of the graptolites; methods of investigation and illustration; terminology; vertical range and geographic distribution; mode of existence; ontogeny and reproduction; morphology; histology; classification and phylogeny; synoptic tables; description of species—71 in all, of which 29 are new.

Fauna of the Beekmantown and Chazy formations. For many years before his death Professor Hall hoped for the opportunity to revise his first volume of the *Palaeontology of New York*. Back in the years from 1843 to 1847, when he was engaged in working out the fauna of the older rocks, the collectors were few and the localities but lightly explored. He did a work of the highest merit, but the revolving years have added much to our knowledge of these early faunas, though he found no opportunity to return to them. A

special interest attaches to these early faunas of the earth, and their development in what is now the basin of Lake Champlain is most favorable, though it has not received merited attention. The collections which we have made in this region during the past five years are extensive and are now undergoing review preliminary to a careful reconsideration of the faunas. Actual additions to the numerical status of the faunas prove to be relatively numerous and of much interest, and these are brought together and presented with this report. Dr Ruedemann has been specially concerned in the collection and study of these bodies and has begun the preparation of a series of discussions pertaining thereto. I incorporate in this report some of his papers relating to certain aspects of the cephalopods, and these contributions will be found of more than ordinary interest in their exposition of the structural characters of these creatures. Prof. George H. Hudson of Plattsburg, who has long studied the rocks and fossil faunas of Valcour island, has also cooperated in this work by adding the descriptions of some interesting species discovered by him in the Chazy formation there.

Fossil plants of the paleozoic rocks. In the history of this office no serious effort has been specially directed to acquiring the plant remains found in the New York rock formations. Not that these have been intentionally ignored or overlooked but the collections which we possess have been acquired incidentally to the exploitation of the marine faunas. In the course of years these incidental collections have grown to be of considerable moment and embrace a few specimens of commanding size, such as the so called fern stumps from Gilboa, the gigantic seaweed (Nematoxylon) from Monroe, Orange co. and the great Lepidodendron from Naples—all from the Upper Devonic. Some forty years ago Professor Hall interested Sir William Dawson, who was generally acknowledged the most expert student of Devonic plants in America, in some of the New York material and both at that time and subsequently Sir William published brief accounts of some of our species. Professors D. P. Penhallow and C. S. Prosser have also given incidental attention to this class of fossils, though taken all together but little has been done in

this important and interesting field. During the past year Mr David White, paleobotanist of the United States Geological Survey has given our collections careful examination and has expressed his conviction of their great importance and completeness. It is proposed with the aid of Mr White to elaborate the more interesting part of these plant remains, and he has in accordance with this plan begun preparing an introductory member of a series of papers relating to this subject.

Investigations at Rondout. Some months of the year were required by Mr Gilbert van Ingen for preparing his report on the geologic conditions at Rondout, which has already been published.

Stratigraphic and areal maps

The following is a list of the colored geologic maps of parts of the State on the scale of 1 mile to the inch (with one exception) which have been issued by this department.

Tarrytown and Ramapo sheets
Amsterdam sheet
Parts of Albany and Rensselaer counties
Niagara Falls and vicinity
Becraft mountain, Columbia county
Olean sheet
Portage division in western New York
Union Springs and vicinity

Printed and ready for distribution

Canandaigua-Naples sheet

Ready for publication

Tully sheet
Salamanca sheet
Part of Schoharie sheet
Elmira sheet
Watkins sheet

In preparation

Ithaca sheet
Waverly sheet

On the following topographic sheets work has been recorded and is more or less advanced toward completion.

Auburn	Geneva	Plattsburg
Ausable	Genoa	Richfield
Berne	Greene	Rochester
Buffalo	Hammondsport	Schuylerville
Cambridge	Hoosick	Silver Creek
Cazenovia	Moravia	Skaneateles
Cherry Creek	Mt Morris	Syracuse
Chittenango	Norwich	Troy
Cohoes	Ovid	Wayland
Cortland	Penn Yan	Westfield
Coventry	Phelps	Whitehall
Dunkirk	Pitcher	

Miscellaneous

Fossil trails at Bidwell's crossing. In my last report Prof. J. B. Woodworth gave a brief illustrated account of certain remarkable trails on the surface of the Potsdam sandstone exposed on the farm of B. H. Palmer at Bidwell's crossing near Sciota, Clinton co. These trails are of a type which have frequently before been found in Potsdam strata and were termed by Sir William Logan, Climactichnites—the ladder-shaped track—from the crossbars which traverse it. Some years ago the State Museum undertook to remove a large slab of these trails from a quarry at Port Henry but the sandstone layer bearing them came out in such a fragmentary condition that the pieces could not be matched together and the undertaking was a qualified success. The exposure at Bidwell's crossing was of extraordinary interest in several respects. Over an area measuring about 30 feet in length by 10 feet in width and flush with the soil surface of a partly cleared brush lot lay a series of long trails averaging 5 inches in width and some of them 10 to 15 feet in length, the principal trails having a general parallelism to the length of the exposure, there being not less than 25 distinct trails visible on the slab. Each of these long serpentlike trails, when complete, ends in a distinct oval impression which has been considered by Professor Woodworth as the mark made by the body of the animal at rest. Such terminal

Plate 2

Fossil trails on Potsdam sandstone, Bidwell's Crossing, Clinton co.

markings have not been observed before either independently or in connection with these trails. Twenty-six of these oval scars are shown on the slab. Logan, Hall and other writers on such markings have generally regarded them as made by large trilobites and the undulated crossbars as caused by the oscillating ventral appendages of these animals in crawling over the long exposures of the sand beach at ebb tide. Professor Woodworth, however, believes that they were produced by a worm or large univalve mollusk and has given an account of some experiments made by himself to demonstrate that the markings must have been caused by a single rather than a multiple opposing surface, by the successive undulations of the gastropod foot rather than by the multiple impression of a trilobite's legs. We know in fact neither the remains of a trilobite nor of a gastropod mollusk in these rocks large enough to make such trails. Either may have been present and like the reptiles whose tracks are found by thousands in the Triassic sandstones of the Connecticut valley, have left no other evidence of itself. From theoretic considerations a crawling patelloid gastropod of commanding dimensions would have well fitted the marine fauna of these ancient Cambric times.

This remarkable display of these ancient trails on the sands of the primordial beach which skirted the primitive continent, now the crystalline nucleus of the Adirondack mountains, had been known to the countryside for many years but public attention was drawn to it first by the publication referred to. A singular bit of folk-lore has grown up about the trails as successive generations of settlers have wondered at their nature. I have been seriously informed by a venerable village philosopher that here was the very spot where Christ, in accordance with Pentateuchal prophecy, trod on the Serpent's head, and this interpretation seemed generally accepted in some considerable portion of the community as the true meaning of the trails. The oval scars well simulate the print of the human foot lying at or across the end of the serpentine trails.

The location of so striking a display of these trails afforded us an opportunity for securing them for the museum. Accordingly an agreement was entered into with the owner, Mr Palmer, in the form

of an option of purchase whenever it would become practicable for us to meet the necessary expense attending removal. At a later date I entered into a contract with Frederick Braun for the removal of the principal part of the exposure, having a length of 33 feet and a width of 10 feet. The undertaking was an extraordinarily arduous one, rendered the more difficult by the checking of the sandstone along parallel or converging joint faces which made it necessary to set each block in place in plaster of paris as it was removed. The work of removal required two months and on its completion the exposed slab had been taken out in six sections, the whole weighing 23 tons.

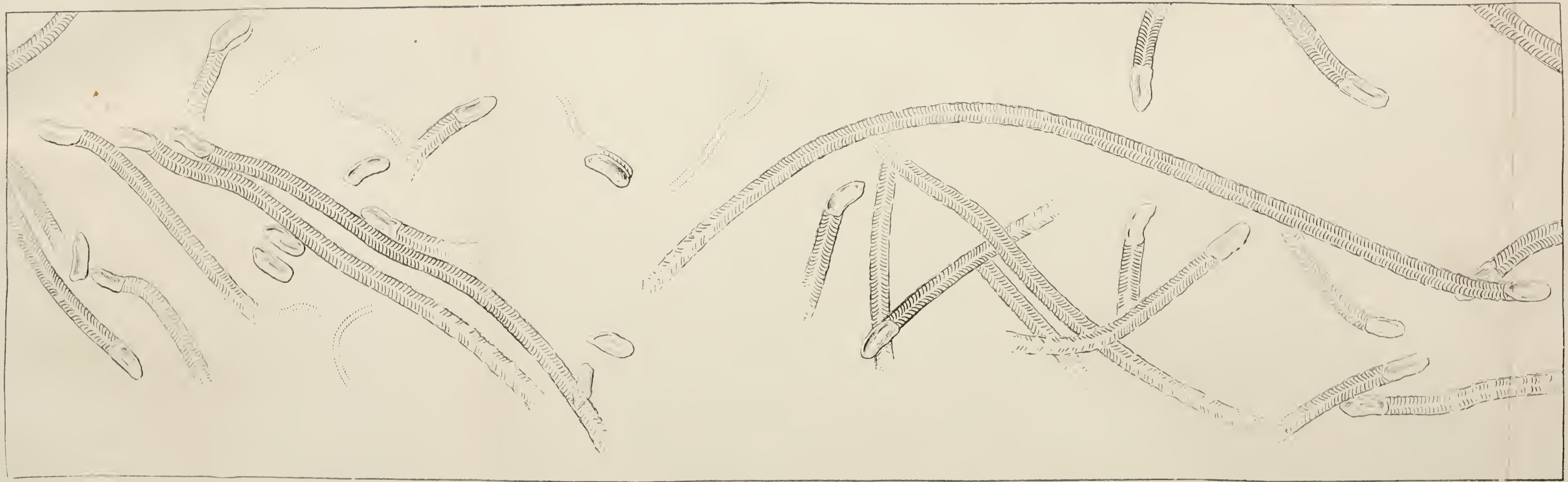
We have in this remarkable specimen an unexampled and impressive exhibit. Facilities for the display of such specimens simply do not exist in the present constitution of our museum but we can not on that account let slip opportunities which may not return, for acquiring such specimens. Storage has been found for these slabs with the Flint Granite Co. at the Cemetery station.

Lease of the Spring House lot. In order to secure for the museum a more extensive series of the rare crustaceans from the base of the Salina group, described by Clifton J. Sarle and myself in previous reports and to facilitate our own further studies of this fauna, I have negotiated a lease of the property adjoining the Erie canal at Pittsford for the purpose of excavating these remarkable fossils. We purpose to break ground at this place with the opening of the next field season.

Proposed salt mine at Wyoming. During the past year it was proposed by the Silver Springs Salt Co. to put down a shaft for mining rock salt at Wyoming, Wyoming co. A company was organized for this purpose with the name Oatka Salt Co. under the management of John H. Duncan.

The section of the rock strata compiled by us some years ago from the Livonia salt shaft afforded the most complete information of the rock succession and sequence of faunas through 1600 feet of strata yet recorded in this State. It would be an important contribution to this science if we could duplicate and supplement this elaborate section, and consequently I entered into an understanding with

Plate 3



Trails on Potsdam sandstone, Bidwell's Crossing, Clinton co. Sketch made before removal. One twenty-eighth natural size.

Mr Duncan, by whose courtesy we were to be permitted to carry on our examinations and collections during the sinking of the shaft. Since the date of this arrangement Mr Duncan has retired from the management of the company and comparatively little progress has been made in carrying out the original plans for excavation. Should, however, the undertaking be continued we expect to prosecute our examination as originally purposed.

Proposed exhibit for the St Louis Exposition. At the request of the state commission proposals have been made in various form for an exhibition of the work of this department. The proposition which has seemed to best meet the approbation of the commissioners involves the exhibit of the slab of trails from the Potsdam sandstone, already described, supplemented by a series of our publications. I have been authorized to proceed with the preparation of this exhibit.

Purchase of the Ruedemann collection. Previous to his appointment on the staff of this division Dr Ruedemann had brought together an interesting collection of Silurian fossils from this State, in which was included the material utilized as the basis of his study of the graptolites and Conularia. We have acquired this collection by purchase and it constitutes one of the important acquisitions of the year, its type specimens being both numerous and important. A list of its contents is given in full among the accessions.

Appointment of lithographer. By the death of Philip Ast, who had been connected with this department as lithographer for upward of thirty years, it became necessary to fill the vacancy under the civil service requirements. In due conformity therewith William S. Barkentin has been appointed to the position.

Present staff

Permanent and temporary

John M. Clarke, state paleontologist
Rudolf Ruedemann, assistant state paleontologist
D. D. Luther, field assistant
George S. Barkentin, draftsman
William S. Barkentin, lithographer
Jacob Van Deloo, clerk

Martin Sheehy, general assistant

Horatio S. Mattimore, preparator

Gilbert van Ingen, special assistant in cooperation with State Engineer and Surveyor

Amadeus W. Grabau
George H. Chadwick
C. A. Hartnagel
P. Edwin Clark
Frederick Braun

engaged in special field operations

In the following appendixes are given the list of accessions to the museum by collection, purchase and gift, the list of new localities represented by these accessions and a supplementary list of type specimens of species, added to the museum collections since the publication of the catalogue of types.

Respectfully submitted

John M. Clarke

State Paleontologist

Oct. 1, 1903

APPENDIX 1

ACCESSIONS

The additions to the paleontologic collections have been by donation, purchase, exchange and collection. A detailed statement of these acquisitions is given herewith.

Donations

Wilson, J. D., Syracuse	
Undescribed gastropod. Agoniatite limestone, Manlius	1
Davis, E. E., Norwich	
Large block of Oneonta sandstone with Orthoceras. Oxford	1
Hall, E. B., Wellsville	
Chemung fossils from Wellsville and vicinity	125
Adams, A. P.	
Coal Measures. San Juan river, S. E. Utah	1
Woodward, A. S., London, Eng.	
Tilestones. Horeb Chapel near Llandovery, Wales	7
Total by donation	135

Purchases

Ward Natural Science Establishment, Rochester		
Pentamerus from Clinton limestone, Rochester; 1 group	1	
Ruedemann, R.		
Specimens of Conularia, Tetradium and graptolites from the Utica shale, Dolgeville, as follows:		
Conularia gracilis	58	(hypotypes)
Tetradium cellulosum	16	(hypotypes)
Diplograptus foliaceus; D. ruedemanni	40	(types and hypotypes)
Kazenstein, Mrs F., Hancock		
Archaeopteris. Oneonta sandstone, Hancock	1	
Total by purchase	116	

Exchanges

van Ingen, G.

Oriskany fossils from Glenerie, Ulster co. 1000

Kayser, Prof. Dr E. Marburg, Germany

Aphyllites inconstans *Phill.* Upper Middle Devonic. Adorf (Westphalia) 1

A. cancellatus *Arch. Vern.* Upper Middle Devonic. Brilon 2

Maeneceras terebratum *Sandb.* Upper Middle Devonic. Finnentrop (Westphalia) 3

M. terebratum *Sandb.* Upper Middle Devonic. Martenberg bei Adorf (Westphalia) 2

Pharciceras tridens *Sandb.* Upper Middle Devonic. Langenaubach near Dillenburg 1

P. (?) clavilobus *Sandb.* Upper Middle Devonic. Grube Constance near Langenaubach 1

Goniatites (Pharciceras) becheri v. *Buch.* Middle Devonic. Grube Constance, Langenaubach near Dillenburg 1

Goniatites simplex. Upper Middle Devonic. Finnentrop 1

G. sphaericus (*Mart.?*) *Kon.* 1880 var. Culm. Hagen (Westphalia) 2

G. (Gephyroceras?) aequabilis. Upper Middle Devonic. Langenaubach near Dillenburg 1

Beloceras kayseri *Holzapf.* Lower Upper Devonic. Oberscheld near Dillenburg 1

B. multilobatum *Beyr.* Lower Upper Devonic. Oberscheld near Dillenburg 2

Tornoceras mithracoides. Upper Middle Devonic. Grube Constanz near Langenaubach 1

T. circumflexiferum *Sandb.* Oderhauserkalk. Upper Middle Devonic. Urfethal (Kellerwald) 3

Triaenoceras costatum *Arch. Vern.* Upper Middle Devonic. Grube Constanz near Langenaubach (Dillenburg) 2

Prolobites delphinus *Sandb.* Clymenia beds. Oberscheld near Dillenburg 3

Discohelix (Euomphalus) rota *Sandb.* Stringocephalenkalk. Finnentrop (Westphalia) 1

Chiloceras subpartitum *Münst.* Nehden stage. Upper Middle Devonic? Cabrières (South France)	3
Bellerophon striatus *Br.* Upper Middle Devonic. Finnentrop (Westphalia)	2
Holopella tenuisulcata *Sandb.* Middle Devonic. Freter Mühle near Finnentrop	3
Spirifer hercyniae *Gieb.* Lower Coblenz beds. Stadtfeld	2
S. hercyniae *Gieb.* var. primaeviformis *Scup.* Lower Coblenz beds. Stadtfeld (Eifel)	1
S. decheni *Kays.* (=fallax *Gieb.*) Hercyn. Lower Devonic. Erbsloch (Kellerwald)	3
S. decheni *Kays.* Hercyn. Lower Devonic. Erbsloch (Kellerwald)	2
S. maureri *Holzapf.* Upper Middle Devonic. Finnentrop (Westphalia)	1
S. hians v. *Buch.* Stringocephalenkalk. Schladethal near Gladbach (Köln)	5
S. malaisei *Goss.* Lower Upper Devonic. Stolberg near Aachen	1
Pentamerus rhenanus *F. Roemer.* Stringocephalenkalk. Greifenstein near Wetzlar	2
P. oehlerti *Barrois.* Middle Devonic. Tentaculite beds. Leun near Wetzlar	2
P. baschkiricus *de Vern.* Middle Devonic. River Ai, Ural mountains	2
Orthis ivanovi *Tschernysch.* Lower Upper Devonic. Stolberg near Aachen	3
Newberria amygdalina *Stein. Goldf.* Stringocephalenkalk. Pelm (Eifel)	2
N. amygdalina *Stein. Goldf.* Lenneschiefer. Attendorn (Westphalia)	1
Amphigenia beyrichi *Holzapf.* Upper Middle Devonic. Finnentrop	1
Meganteris damesi *Holzapf.* Upper Middle Devonic. Finnentrop (Westphalia)	2

Athyris globosa *Roem.* Ibergerkalk. Lower Upper Devonic. Bieber (Nassau)	3
Leptaena retrorsa *Kays.* Lower Upper Devonic. Cornelimünster near Aachen	3
Rhynchonella pugnus *Mart.* Ibergerkalk. Langenaubach	6
Liorhynchus formosus *Schnur.* Lower Upper Devonic. Büdesheim (Eifel)	3
Strophalosia productoides *Murch.* Upper Devonic. Aachen (Rhineland)	3
Amphipora ramosa *Phill.* Upper Stringocephalenkalk. Schladethal near Berg Gladbach (Westphalia)	1
Philipsastraea? roemeri *E. H.* Ibergerkalk. Lower Upper Devonic. Alter Schalsteinbruch, Langenaubach near Dillenburg	3
Proetus eremita *Barr.* Lower Middle Devonic (Mnenianerkalk). Greifenstein	1
P. orbitatus *Barr.* Lower Middle Devonic. Greifenstein. (Mnenianerkalk). Greifenstein	1
Dechenella verneuili *Barr.* Stringocephalekalk. Pelm (Gerolstein)	2
Cheirurus cf. sternbergeri *Barr.* Upper Middle Devonic. Grube "Martha" near Wetzlar	3
Odontochile hassiaca *Kays.* Upper Lower Devonic or Lower Middle Devonic? Kleinlinden near Giessen	1
Phacops caecus *Gürich.* Upper Devonic. Langenaubach near Dillenburg	3
Harpes gracilis *Sandb.* Intumescens zone. Sessacker near Oberscheld	1
Posidonia venusta *Münst.* Upper Upper Devonic. Sessacker near Oberscheld	1
Buchiola aquarum *Beush.* Upper Middle Devonic (Odershäuserkalk). Wildungen	1
Kochia dispar *Sandb.* Upper Upper Devonic. (Clymenienkalk). Oberscheld	3
Chascothyris barroisi *Holzapf.* Upper Middle Devonic. Finnentrop (Westphalia)	1
Total by exchange	1106

Collections

The paleontologist	
Devonian and Silurian rocks, Percé, Quebec	700
Hamilton fossils from Adamsdale Pa.	10
Ruedemann, R.	
Beekmantown and Chazy fossils from Clinton county	4000
Ruedemann, R. and van Ingen, G.	
Oriskany fossils from Glenerie, Ulster co.	600
Luther, D. D. and Mattimore, H. S.	
Upper Devonic fossils from the Elmira, Watkins, Waverly and Ithaca quadrangles	1500
Mattimore, H. S.	
Trenton limestone, Watertown N. Y.	175
Black river limestone, Brownsville N. Y.	15
Hartnagel, C. A.	
Cobleskill limestone fossils from Orange and Ulster county	1200
van Ingen, G.	
Rondout, Manlius and Helderbergian from Rondout and vicinity	800
Chadwick, G. H.	
Fossils from the Esopus grit. Athens-Leeds turnpike, Greene county	100
Port Ewen beds, South Rondout	129
Catskill shale, Summit cut, Delhi & Andes Railway, Delaware county	36
Ithaca beds, bed of Town brook, Hobart, Delaware co.	17
Total by collection	9282
Total accessions	10639 (2 types; 112 hypotypes)

APPENDIX 2

NEW ENTRIES ON GENERAL RECORD OF LOCALITIES OF AMERICAN PALEOZOIC FOSSILS BELONGING TO THE STATE MUSEUM

ALPHABETIC LIST OF LOCALITIES

Accord (Orange co.), 3316, 3317, 3318, 3319

Adamsdale Pa., 3306

Argusville (Schoharie co.), 3254

Athens (Greene co.), 3284

NEW YORK LOCALITIES ACCORDING TO COUNTIES

Names in italic are new to the record

Allegany co.
Wellsville
Clinton co.
Beekmantown
East Beekmantown
Chazy
Cooperville
Ingraham
Kings bay
Little Monty bay
Valcour island
West Chazy
Columbia co.
Hudson
Mt Moreno
Delaware co.
Hobart
Greene co.
Athens
Catskill
Collar Back hill
Green lake
Leeds
Herkimer co.
Litchfield
Jefferson co.
Brownville
Watertown
Livingston co.
Union Corners
Onondaga co.
Onondaga
Ontario co.
Geneva

INDEX TO FORMATIONS

Upper Siluric, 3297, 3301

Siluric, 3299, 3300, 3311, 3312, 3313, 3315, 3316

Guelph dolomite, 3325

Wilbur limestone, 3258, 3259, 3261, 3264, 3265, 3268, 3269, 3271, 3272, 3273, 3275, 3276, 3318

Bertie waterlime, 3231

Rondout waterlime, 3239, 3241, 3245, 3257, 3266

Cobleskill limestone, 3233, 3234, 3235, 3236, 3237, 3238, 3240, 3241, 3242, 3243, 3244, 3245, 3246, 3247, 3248, 3249, 3250, 3251, 3252, 3253, 3254, 3255, 3256, 3260, 3262, 3263, 3267, 3270, 3274, 3277, 3278, 3308, 3309, 3310, 3314, 3317, 3319, 3320, 3321

Manlius limestone, 3322

Lower Devonic?, 3301

Helderbergian, 3324

New Scotland beds, 3324

Port Ewen limestone, 3285, 3286, 3287, 3288, 3289, 3290

Oriskany sandstone, 3280, 3281, 3296, 3323

Esopus grit, 3284

Onondaga limestone, 3279

Hamilton beds, 3306

Portage beds, 3283, 3293, 3294, 3295, 3342, 3343, 3344, 3345, 3346, 3347, 3348, 3349, 3350, 3351, 3352, 3353, 3354, 3355, 3356, 3357, 3358, 3359, 3360, 3361, 3362

Naples shales, 3283

Ithaca beds, 3294, 3307, 3346, 3347, 3348, 3349, 3350, 3352, 3359, 3361

Chemung beds, 3232

Catskill beds, 3291

Carbonic, 3304

Coal Measures, 3282

RECORD OF LOCALITIES

3231 Bertie waterlime. 1 m. north of Cherry Valley. C. A. Hartnagel, collector. 1902.

3232 Chemung beds. Near Wellsville. E. B. Hall, donor. 1902.

3233 Cobleskill limestone. Shutters Corners, 3 m. east of Schoharie, on farm of Seth Stevens. C. A. Hartnagel, collector. 1902.

3234 Cobleskill limestone. Outcrops 1½ m. northeast of Schoharie and ½ m. south of Fox creek. C. A. Hartnagel, collector. 1902.

3235 Cobleskill limestone. Outcrops on hillside ¼ m. northeast of Mix and O'Reilly's quarry at Schoharie. C. A. Hartnagel, collector. 1902.

3236 Cobleskill limestone. Brown's quarry, north of road ¼ m. southeast of Schoharie postoffice. From the 38 in. basal layer of the Cobleskill. C. A. Hartnagel, collector. 1902.

3237 Cobleskill limestone. Brown's quarry. Fossils from the 16 in. layer above basal layer. C. A. Hartnagel, collector. 1902.

3238 Cobleskill limestone. Brown's quarry. Thin layers of limestone at top of Cobleskill, grading into the cement rock above. C. A. Hartnagel, collector. 1902.

3239 Rondout. E. Vroman's quarry. 150 yd southwest of Brown's quarry. Fossils from limestone intercalated in Rondout, 5 ft above top of Cobleskill. C. A. Hartnagel, collector. 1902.

3240 Cobleskill limestone. Clark's cave, ⅓ m. north of Schoharie creek bridge, Schoharie. C. A. Hartnagel, collector. 1902.

3241 Rondout. In the drab colored layers, 6 ft thick, above the Cobleskill limestone at Clark's cave, Schoharie. C. A. Hartnagel, collector. 1902.

3242 Cobleskill limestone. Northeast point of West mountain, 2 m. north of Schoharie. C. A. Hartnagel, collector. 1902.

3243 Cobleskill limestone. Outcrop on West mountain, 1 m. south of Central Bridge, Schoharie co. C. A. Hartnagel, collector. 1902.

3244 Cobleskill limestone. Roadside near old tunnel at Howes Cave, Schoharie co. C. A. Hartnagel, collector. 1902.

3245 Rondout. In cement beds just above the Cobleskill limestone at Howes Cave. C. A. Hartnagel, collector. 1902.

3246 Cobleskill limestone. Exposure in small creek, 1 m. northeast of Howes Cave. C. A. Hartnagel, collector. 1902.

3247 Cobleskill limestone. Tarr's farm, 1½ m. northeast of Howes Cave. C. A. Hartnagel, collector. 1902.

3248 Cobleskill limestone. On farm of Eugene Maxwell, 2½ m. north of Howes Cave. C. A. Hartnagel, collector. 1902.

3249 Cobleskill limestone. Farm of Judson Grovenor, 3 m. north of Howes Cave. C. A. Hartnagel, collector. 1902.

3250 Cobleskill limestone. Grovenor Corners, 1 m. west of 3249 and 3 m. directly north from Howes Cave. C. A. Hartnagel, collector. 1902.

3251 Cobleskill limestone. Roadside 1 m. northwest of Grovenor Corners, Schoharie co. C. A. Hartnagel, collector. 1902.

3252 Cobleskill limestone. In field by roadside, 1 m. northwest from Carlisle village, Schoharie co. C. A. Hartnagel, collector. 1902.

3253 Cobleskill limestone. South of highway, 2½ m. northwest from Carlisle. C. A. Hartnagel, collector. 1902.

3254 Cobleskill limestone. 3 m. east of Sharon Springs, south of highway leading to Argusville. C. A. Hartnagel, collector. 1902.

3255 Cobleskill limestone. Fossils from north end of Collar Back hill, 1 m. west of Catskill, Greene co. C. A. Hartnagel, collector. 1902.

3256 Cobleskill limestone. West Shore Railroad cut, Greene co., 1 m. north of West Camp, Ulster co. C. A. Hartnagel, collector. 1902.

3257 Rondout, base of. 1 m. north of West Camp, Greene co. C. A. Hartnagel, collector. 1902.

3258 Wilbur limestone. South end of syncline which terminates a short distance west of West Camp station. C. A. Hartnagel, collector. 1902.

3259 Wilbur limestone. West limb of syncline, 1 m. northwest of West Camp, Ulster co., near the county line. C. A. Hartnagel, collector. 1902.

3260 Cobleskill limestone. 1 m. west of Glasco, Ulster co. C. A. Hartnagel, collector. 1902.

3261 Wilbur limestone. Old quarry entrance, 1 m. north of East Kingston, Ulster co. C. A. Hartnagel, collector. 1902.

3262 Cobleskill limestone. ¾ m. north of East Kingston. C. A. Hartnagel, collector. 1902.

3263 Cobleskill limestone, top of. At "Steep Rocks," 1 m. north of Rondout, Ulster co. C. A. Hartnagel, collector. 1902.

3264 Wilbur limestone. East side of the "Vlightberg," Rondout. C. A. Hartnagel, collector. 1902.

3265 Wilbur limestone, top of the. South end of the "Vlightberg," Rondout. C. A. Hartnagel, collector. 1902.

3266 Rondout. Middle limestone or Leperditia layer at the "Vlightberg," Rondout. C. A. Hartnagel, collector. 1902.

3267 Cobleskill limestone. Across Rondout creek, opposite Wilbur, Ulster co. C. A. Hartnagel, collector. 1902.

3268 Wilbur limestone. Along highway ½ m. southwest from Eddyville, Ulster co. C. A. Hartnagel, collector. 1902.

3269 Wilbur limestone. Railroad cut 1 m. southwest of Whiteport station, Ulster co. C. A. Hartnagel, collector. 1902.

3270 Cobleskill limestone. ¼ m. north of Binnewater station, Ulster co. C. A. Hartnagel, collector. 1902.

3271 Wilbur limestone. Vertical layers exposed at old cement mine west of Creek Locks, Ulster co. C. A. Hartnagel, collector. 1902.

3272 Wilbur limestone. 1 m. northeast of Rosendale, Ulster co., at cement mine. C. A. Hartnagel, collector. 1902.

3273 Wilbur limestone. Sandy layers at base of the cement, Rosendale. C. A. Hartnagel, collector. 1902.

3274 Cobleskill limestone. Rosendale. C. A. Hartnagel, collector. 1902.

3275 Wilbur limestone. Thin layer below cement beds, High Falls, Ulster co. C. A. Hartnagel, collector. 1902.

3276 Wilbur limestone. Below cement bed at High Falls, Ulster co. C. A. Hartnagel, collector. 1902.

3277 Cobleskill limestone. High Falls, Ulster co. C. A. Hartnagel, collector. 1902.

3278 Cobleskill limestone. Black shaly layer at top of Cobleskill, southwest from Eddyville, Ulster co., at old cement mine. C. A. Hartnagel, collector. 1902.

3279 Onondaga limestone. 2 m. north of Geneva, Ontario co. H. C. Magnus, collector. 1902.

3280 Oriskanian. Along roadside, right bank of Esopus creek north of Glenerie, Ulster co., near Mt Marion station. R. Ruedemann and G. van Ingen, collectors. 1899.

3281 Oriskanian. Along roadside, right bank of Esopus creek, for ½ m. north of old Ulster White Lead Co. at Glenerie, near Mt Marion station. G. van Ingen, exchange. 1903.

3282 Coal Measures. Southeastern Utah; San Juan river. A. P. Adams, donor. 1903.

3283 Portage (Naples). Union Corners, Livingston co. J. M. Clarke, collector. 1890.

3284 Esopus. Athens–Leeds turnpike, Greene co., just west of road to Green lake; from lower 40 ft of grit rock usually referred to Esopus, but having more distinct bedding. Marly layer with numerous fossils is near top of section, 3 ft below Esopus. G. H. Chadwick, collector. 1903.

3285 Port Ewen beds. South Rondout, quarried masses of lower members, north end of hill near Rondout creek. G. H. Chadwick, collector. 1903.

3286 Port Ewen beds. Loose blocks from hanging wall of Port Ewen in upper quarry toward Rondout creek, South Rondout. G. H. Chadwick, collector. 1903.

3287 Port Ewen beds. Loose at South Rondout. G. H. Chadwick, collector. 1903.

3288 Port Ewen beds. West quarry, Zoller's hill, South Rondout. G. H. Chadwick, collector. 1903.

3289 Port Ewen beds. Mouth of cave, west end of Zoller's hill, South Rondout. G. H. Chadwick, collector. 1903.

3290 Port Ewen beds. Hanging wall of Becraft limestone quarry, South Rondout. G. H. Chadwick, collector. 1903.

3291 Catskill shale. Summit cut, Delhi & Andes Railway, Delaware co. Green shales near middle section; red shales at top. G. H. Chadwick, collector. 1903.

3292 Beekmantown graptolite shales. Ash hill quarry, Mt Moreno, near Hudson N. Y. R. Ruedemann, collector. 1903.

3293 Portage. Quarry on roadside, road running from Montour Falls to Watkins, west side of valley, ¼ m. south of fair grounds. D. D. Luther and H. S. Mattimore, collectors. 1903.

3294 Portage. (Ithaca). Quarry 1 m. northeast of Montour Falls. D. D. Luther and H. S. Mattimore, collectors. 1903.

3295 Portage. Havana glen. Foot of Portal cascade. D. D. Luther and H. S. Mattimore, collectors. 1903.

3296 Red, yellow and drab limestones of the Grande Grève series (Oriskany). Percé rock, Percé, P. Q. J. M. Clarke, collector. 1903.

3297 Gray, thin bedded limestone with intercalated shales. North end of Mt Joli Percé P. Q. Upper Siluric. J. M. Clarke, collector. 1903.

3298 Gray arenaceous limestones with interbedded shales. South flank of Mt Joli, Percé P. Q. Lower Siluric. J. M. Clarke, collector. 1903.

3299 Limestones of Cap Blanc. Thin slabs from the middle and lower or south end of the section. Percé P. Q. J. M. Clarke, collector. 1903.

3300 Limestones of Cap Blanc. Red limestone from the upper or north end of the section. Percé P. Q. J. M. Clarke, collector. 1903.

3301 Gray calcareous shales with thin limestones. Upper Siluric (Lower Devonic?). Percé P. Q. Cape Barré; north end of North Beach. J. M. Clarke, collector. 1903.

3302 Blow Hole on sea wall north of North Beach, Percé P. Q. Equivalent in age to the Percé rock. J. M. Clarke, collector. 1903.

3303 Nodular limestones and limestone conglomerate with fossils of the Percé rock. Le Coulé, Percé P. Q. J. M. Clarke, collector. 1903.

3304 Bonaventure conglomerate. Mt St Anne and other localities. Pebbles containing the fossils of Percé rock and others of earlier date. Percé P. Q. J. M. Clarke, collector. 1903.

3305 Limekiln escarpment back of Cape Cannon. Heavy bedded limestone, massive, with Lower Siluric fossils. J. M. Clarke, collector. 1903.

3306 Hamilton shales. At Adamsdale, Schuylkill co. Pa. J. M. Clarke, collector. 1903.

3307 Ithaca beds. Loose in bed of Town brook. Hobart, Delaware co. G. H. Chadwick, collector. 1903.

3308 Cobleskill limestone. Field west of house of Mr Case, 1½ m. southwest of Otisville, Orange co. C. A. Hartnagel, collector. 1903.

3309 Cobleskill limestone. 1 m. east of Cuddebackville, Orange co., near old limekiln. C. A. Hartnagel, collector. 1903.

3310 Cobleskill limestone. Old quarry just west of 3309; transient into Rondout waterlime. C. A. Hartnagel, collector. 1903.

3311 Decker Ferry beds. Outcrop in lane leading diagonally up the bluff on Nearpass farm, 3 m. south of Port Jervis, Orange co. C. A. Hartnagel, collector. 1903.

3312 Decker Ferry beds. Fossils from near base of bluff on Nearpass farm 3 m. south of Port Jervis. C. A. Hartnagel, collector. 1903.

3313 Decker Ferry beds. Fossils from red crystalline limestone on Nearpass farm 3 m. south of Port Jervis. C. A. Hartnagel, collector. 1903.

3314 Cobleskill limestone. Fossils from 6 foot band just below Rondout waterlime, Nearpass farm 3 m. south of Port Jervis. C. A. Hartnagel, collector. 1903.

3315 Bossardville limestone; below Decker Ferry formation. Nearpass farm 3 m. south of Port Jervis. C. A. Hartnagel, collector. 1903.

3316 Decker Ferry beds. Fossils from Chonetes jerseyensis zone in cut of Ontario & Western Railroad, ½ m. southwest of Accord, Ulster co. C. A. Hartnagel, collector. 1903.

3317 Cobleskill limestone. Fiddler's Elbow on Delaware & Hudson canal, ½ m. southwest of Accord. C. A. Hartnagel, collector. 1903.

3318 Wilbur limestone horizon. Basal arenaceous layer above which is found Cobleskill limestone with typical Cobleskill fauna. Fiddler's Elbow on Delaware & Hudson canal, ½ m. southwest of Accord. C. A. Hartnagel, collector. 1903.

3319 Cobleskill limestone. Cut on Ontario & Western Railroad, ½ m. southwest of Accord. C. A. Hartnagel, collector. 1903.

3320 Cobleskill limestone. On Joseph Chipp farm, ¼ m. north of Kerhonkson, Ulster co. C. A. Hartnagel, collector. 1903.

3321 Cobleskill limestone. Wheelock farm, Litchfield, Herkimer co. C. A. Hartnagel, collector. 1903.

3322 Manlius limestone. Nearpass quarry, 3 m. south of Port Jervis. C. A. Hartnagel, collector. 1903.

3323 Oriskany sandstone. Benjamin C. Smailes farm, 5 m. northeast of Ellenville, Ulster co. C. A. Hartnagel, collector. 1903.

3324 Helderbergian. John Hornbeek quarry, a short distance south of Eastern Reformatory at Napanoch, Ulster co. The presence of Leptaenisca adnascens H. & C. indicates the New Scotland age of these beds. C. A. Hartnagel, collector. 1903.

3325 Guelph dolomite. Niagara falls, Canadian side. Exposure made by the Ontario Power Co. C. A. Hartnagel, collector. 1903.

3326 Beekmantown beds. Kirby ledge near East Beekmantown, south of county poorhouse. Station 227. R. Ruedemann, collector. 1903.

3327 Beekmantown beds. Spelman ledge near East Beekmantown. Station 228. R. Ruedemann, collector. 1903.

3328 Beekmantown beds. From ridge crossing the road from West Chazy to Ingraham. Station 230. R. Ruedemann, collector. 1903.

3329 Upper Chazy beds. From exposures on the road from Ingraham to Beekmantown, 1½ m. west of Ingraham. Station 232. R. Ruedemann, collector. 1903.

3330 Lower Chazy beds. On Nightingale farm near Chazy village. From A, B, and C of Brainerd and Seely's sections 1 and 2. R. Ruedemann, collector. 1903.

3331 Middle Chazy beds. Chazy village. West of Little Monty bay. Station 233. R. Ruedemann, collector. 1903.

3332 Chazy conglomerate. Boulder on road from Coopersville station to King's bay. Station 234. R. Ruedemann, collector. 1903.

3333 Lower Chazy bed. West of Chazy and north of road leading from Chazy to West Chazy. Station 237. A5. R. Ruedemann, collector. 1903.

3334 Lower Chazy bed. Red spot, layer of A8, exposed half way between Chazy and West Chazy. Station 239. R. Ruedemann, collector. 1903.

3335 Middle Chazy bed. From ridge extending north of road from Chazy to West Chazy. Station 240. R. Ruedemann, collector. 1903.

3336 Middle Chazy bed. Along west side of Valcour island, from first promontory south of Laclaire farm to exposure at southermost cove. Station 241. R. Ruedemann, collector. 1903.

3337 Middle Chazy bed. Southwest corner of Valcour island. Maclurea bed with silicified fossils. Station 242, 1. R. Ruedemann, collector. 1903.

3338 Middle Chazy bed. Valcour island. Exposure on lake shore, directly north of Christmas farm. Station 243, 1. R. Ruedemann, collector. 1903.

3339 Upper Chazy bed. ½ m. south of farm of Judson Trembly, behind schoolhouse at Little Monty bay. Station 243. R. Ruedemann, collector. 1903.

3340 Coal Measures. Mazon creek, Illinois. Dr Joseph Simms, donor. 1903.

3341 Agoniatite limestone. Onondaga, Onondaga co. John D. Wilson, donor. 1904.

3342 Portage. Outcrop on road running on west side of Cayuga lake below railroad ¼ m. south of head of lake; ½ m. north of Ithaca N. Y. (390 ft A. T. A1) D. D. Luther and H. S. Mattimore, collectors. 1903.

3343 Portage. Southwest corner of Cayuga lake; cliff 10 ft above lake; 1 m. north of Ithaca. (387 ft A. T. A2) D. D. Luther and H. S. Mattimore, collectors. 1903.

3344 Portage. Just north of Williams brook, 20 ft above lake. (298 ft A. T. A3) D. D. Luther and H. S. Mattimore, collectors. 1903.

3345 Portage. Old quarry along railroad, ½ m. south of Williams brook, Tompkins co. (393 ft A. T. A4) D. D. Luther and H. S. Mattimore, collectors. 1903.

3346 Portage (Ithaca). Quarry no. 1 above railroad, 1 m. south of fair grounds, Ithaca. (525–560 ft A. T. B1) D. D. Luther and H. S. Mattimore, collectors. 1903.

3347 Portage (Ithaca). Roadside outcrop above quarry no. 1. (580 ft A. T. B2) D. D. Luther and H. S. Mattimore, collectors. 1903.

3348 Portage (Ithaca). Quarry no. 2, 1 m. northeast of quarry no. 1. (580 ft A. T. B3) D. D. Luther and H. S. Mattimore, collectors. 1903.

3349 Portage (Ithaca). On highway leading southwest from Lehigh Railroad station at Ithaca; 1/8 m. from station. (500 ft A. T. B4) D. D. Luther and H. S. Mattimore, collectors. 1903.

3350 Portage (Ithaca). Roadside outcrop on Hector street, Ithaca. (540 ft A. T. B4) D. D. Luther and H. S. Mattimore, collectors. 1903.

3351 Portage. Along Cliff street, Ithaca; 1/2 m. from Lehigh Railroad station. B6. D. D. Luther and H. S. Mattimore, collectors. 1903.

3352 Portage. Quarry no. 3, north of Buttermilk creek and south of Ithaca. (750 ft A. T. C2) D. D. Luther and H. S. Mattimore, collectors. 1903.

3353 Portage. Outcrop on roadside leading up hill 1 m. south of Ithaca. C1. D. D. Luther and H. S. Mattimore, collectors. 1903.

3354 Portage. Buttermilk creek; fossils collected in creek bed at lower falls. (460–500 ft A. T. C3) D. D. Luther and H. S. Mattimore, collectors. 1903.

3355 Portage. Base of Buttermilk falls, Tompkins co. (400 ft A. T. C4) D. D. Luther and H. S. Mattimore, collectors. 1903.

3356 Portage. Quarry no. 4 (Fowler's) on lower road, 1/2 m. south of Ithaca. C5. D. D. Luther and H. S. Mattimore, collectors. 1903.

3357 Portage. Quarry no. 5 (Sheehy's), a short distance northeast of quarry no. 4. C6. D. D. Luther and H. S. Mattimore, collectors. 1903.

3358 Portage. Quarry no. 6, 1/4 m. southeast of fair grounds, Ithaca. (725–800 ft A. T. D1) D. D. Luther and H. S. Mattimore, collectors. 1903.

3359 Portage (Ithaca). Glenwood ravine west side of Cayuga lake, 4 m. north of Ithaca. (440–450 ft A. T. E1, 490 ft A. T. E2, 535 ft A. T. E3, 588 ft A. T. E4, 640 ft A. T. E5, 750 ft A. T. E6) D. D. Luther and H. S. Mattimore, collectors. 1903.

3360 Portage. Esty glen, east side of Cayuga lake, 4 m. north of Ithaca. F1. D. D. Luther and H. S. Mattimore, collectors. 1903.

3361 Portage (Ithaca). MacKinney's glen, east side of Cayuga lake, 2 m. north of Ithaca. (20 ft G1, 55 ft G2, 75 ft G3, 130 ft above lake G4)

3362 Portage. East side of Cayuga lake, ½ m. north of MacKinney's station. (10 ft above lake H1) D. D. Luther and H. S. Mattimore, collectors. 1903.

3363 Trenton limestone. Small quarry west end of Front street near Sloath and Greenleaf's lumber yard, north bank of Black river, Watertown N. Y. H. S. Mattimore, collector. 1902.

3364 Trenton limestone. North side of Black river near water edge, Front street, opposite Babcock & Co.'s carriage factory, Watertown N. Y. H. S. Mattimore, collector. 1902.

3365 Black river limestone. Small quarry 100 yd east of river bridge at Brownville, Jefferson co. N. Y. H. S. Mattimore, collector. 1902.

RECORD OF FOREIGN LOCALITIES

Specimens bearing lemon-yellow tickets

124 Old red sandstone flags. Stromness, Scotland. J. M. Clarke, collector. 1902.

125 Old red sandstone flags. Sandwich, Orkney islands. Purchased.

126 Old red sandstone. Cromarty, Scotland. J. M. Clarke, collector. 1902.

127 Old red sandstone flags. Thurso, Scotland. Purchased.

128 Tilestones. Horeb Chapel, near Llandovery, Wales. A. S. Woodward, donor. 1903.

APPENDIX 3

CATALOGUE OF

TYPE SPECIMENS OF PALEOZOIC FOSSILS[1]

Supplement 1

PLANTAE

PSILOPHYTON Dawson

Psilophyton princeps Dawson

5160 $\frac{290}{1}$ TYPE (unnamed) Vanuxem. Geological survey of New York; report on the 3d district. 1842. p.161.

Psilophyton princeps Dawson. Quarterly journal of the Geological society of London. 1859. 18 : 479.

Hamilton beds ? North New Berlin, Chenango co. N. Y.

Geological survey collection

COELENTERATA

SPONGIAE

HYPHANTAENIA Vanuxem

Hyphantaenia chemungensis Vanuxem (sp.)

5161 $\frac{2360}{5}$ HYPOTYPE Hall & Clarke. New York state museum memoir 2. 1898. pl.45, fig.1.

Chemung beds Union, Broome co. N. Y.

Oberlin College exchange

ECHINODERMATA

Cyathocrinus ornatissimus *see* Scytalocrinus ornatissimus

MELOCRINUS Goldfuss

Melocrinus clarkei (Hall mss.) Williams

439 $\frac{4340}{1}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.D, E.

Genesee shale Canandaigua lake, N. Y.

J. M. Clarke, donor

[1] The body of the catalogue was published as Museum bulletin 65. 1903.

PENTREMITES Say

Pentremites leda Hall

5162 $\frac{4420}{3}$ HYPOTYPE Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.1, fig.1.
Tully pyrite Canandaigua lake, N. Y.
D. D. Luther, coll.

SCYTALOCRINUS Wachsmuth & Springer

Scytalocrinus ornatissimus Hall (sp.)

5163 $\frac{4530}{1}$ HYPOPLASTOTYPE Cyathocrinus ornatissimus Hall (sp.) Geology of New York; report on the 4th district. 1843. p.247, fig. 108.
Scytalocrinus ornatissimus Clarke. New York state museum memoir 6. 1903. pl.F.
Portage (Naples) beds
Lake Erie shore, Portland N. Y.

VERMES

COLEOLUS Hall

Coleolus (?) spinulus Hall

5164 $\frac{5065}{1}$ TYPE Coleolus (?) spinulus Hall. Transactions of the Albany institute. 1881. 10:18 (abstract)
Hall. 11th annual report of the Indiana state geologist. pl.33, fig 8.
Niagaran Waldron Ind.

PALAEOCHAETA Clarke

Palaeochaeta devonica Clarke

5165 $\frac{5151}{1}$ TYPE Palaeochaeta devonica Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1238, pl.28, fig.2.
Portage beds Grimes gully, Naples N. Y.
J. M. Clarke, donor. 1901

5166 $\frac{5151}{2}$ TYPE Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.28, fig.3.
Portage beds Tannery gully, Naples N. Y.
D. D. Luther, coll. 1902

5167 $\frac{5151}{3}$ TYPE Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.28, fig.4.
Portage beds Tannery gully, Naples N. Y.
D. D. Luther, coll. 1902

PROTONYMPHA Clarke

Protonympha salicifolia Clarke

5168 $\frac{5210}{1}$ TYPE (original and counterpart) Protonympha salicifolia Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1237, pl.27, fig.1, 2.
Portage (West hill sandstones)
Italy hill, Yates co. N. Y.
D. D. Luther, coll. 1902

5169 $\frac{5210}{2}$ TYPE (original and counterpart) Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.27, fig.3, 4.
Portage beds Tannery gully, Naples N. Y.
D. D. Luther, coll. 1902

5170 $\frac{5210}{3}$ TYPE: PLASTOTYPE Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.28, fig.1.
Portage beds Italy hill, Naples N. Y.
D. D. Luther, coll. 1902

TENTACULITES Schlotheim

Tentaculites bellulus Hall (?) *mut.* stebos Clarke

5171 $\frac{5286}{1}$ HYPOTYPE Orthoceras stebos Clarke. United States geological survey bulletin 16. 1885. p.29.
Tentaculites bellulus Hall (?) mut. stebos Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.5, fig.8.
Tully pyrite Livonia salt shaft, Livonia N. Y.
D. D. Luther, coll. 1891

Tentaculites gracilistriatus Hall *mut.* asmodeus Clarke

5172 $\frac{5287}{1}$ HYPOTYPE Orthoceras asmodeus Clarke. United States geological survey bulletin 16. 1885. p 31.
Tentaculites gracilistriatus Hall mut. asmodeus Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.4, fig.11.
Tully pyrite Livonia salt shaft, Livonia N. Y.
D. D. Luther, coll. 1891

Tentaculites tenuicinctus F. A. Roemer

5173 $\frac{5288}{1}$ HYPOTYPE Tentaculites tenuicinctus F. A. Roemer. Beitr. 1 zur geol. Kenntnisse d. nordw. Harzgebirges. 1850. p.28.

Clarke. New York state museum memoir 6. 1903. pl.20, fig.20.

Portage (Naples) beds Naples, Ontario co. N. Y.
J. M. Clarke, donor

On slab with original of pl.20, fig. 21.

5174 $\frac{5288}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.21.

Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

On slab with original of pl.20, fig.20.

BRYOZOA

FENESTELLA Lonsdale

Fenestella pertenuis Hall

5175 $\frac{6397}{1}$ TYPE (of description) Fenestella pertenuis Hall. Transactions of the Albany institute. 1881. 10:6 (abstract).

Hall. 11th annual report of the Indiana state geologist. 1881. p.251.

Niagaran Waldron Ind.

On slab with type of Stictopora orbipora, Ind. state geol. 11th an. rep't, p.248.

STICTOPORA Hall

Stictopora orbipora Hall

5176 $\frac{6900}{1}$ TYPE (of description) Stictopora orbipora Hall. Transactions of the Albany institute. 1881. 10.5 (abstract).

Hall. 11th annual report of the Indiana state geologist. 1881. p.248.

Niagaran Waldron Ind.

On slab with type of Fenestella pertenuis, Ind. state geol. 11th an. rep't, p.251.

BRACHIOPODA

AMBOCOELIA Hall

Ambocoelia umbonata Conrad *mut.* **pluto** Loomis

5177 $\frac{7044}{1}$ TYPE Ambocoelia umbonata Conrad mut. pluto Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.905, pl.2, fig.16–18.
Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

Ambocoelia umbonata Conrad *mut.* **pygmaea** Loomis

5178 $\frac{7045}{1}$ TYPE Ambocoelia umbonata Conrad mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.905, pl.2, fig.13–15.
Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

CAMAROTOECHIA Hall & Clarke

Camarotoechia hudsonica Grabau

5179 $\frac{7224}{1}$ TYPE Camarotoechia hudsonica Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1048, fig.8, a, b.
Manlius limestone
Becraft mountain, Columbia co. N. Y.
A. W. Grabau, coll. 1902

5180 $\frac{7224}{2}$ TYPE Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1048, fig.8c.
Manlius limestone
Becraft mountain, Columbia co. N. Y.
A. W. Grabau, coll. 1902

5181 $\frac{7224}{3}$ TYPE Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1048, fig.8d.
Manlius limestone
Becraft mountain, Columbia co. N. Y.
A. W. Grabau, coll. 1902

CYRTINA Davidson

Cyrtina hamiltonensis Hall *mut.* **pygmaea** Loomis

5182 $\frac{7387}{1}$ TYPE Cyrtina hamiltonensis Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.904, pl.3, fig.16.
Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

Leiorhynchus? hecate *see* Spirifer mucronatus *mut.* hecate

NUCLEOSPIRA Hall

Nucleospira concinna Hall *mut.* **pygmaea** Loomis

5183 $\frac{7843}{1}$ TYPE Nucleospira concinna Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.904, pl.1, fig.4; pl.2, fig.5.
Tully pyrite — Greigsville, Livingston co. N. Y.
D. D. Luther, coll.

Orbicula concentrica *see* Ontaria concentrica

PRODUCTELLA Hall

Productella spinulicosta Hall *mut.* **pygmaea** Loomis

5184 $\frac{8095}{1}$ TYPE Productella spinulicosta Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.907, pl.2. fig.11.
Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

RHYNCHOSPIRA Hall

Rhynchospira excavata Grabau

5185 $\frac{8212}{1}$ TYPE Rhynchospira excavata Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1050, fig.9a-c.
Manlius limestone — Mt Bob, Columbia co. N. Y.
A. W. Grabau, coll. 1902

SPIRIFER Sowerby

Spirifer belphegor *see* Spirifer tullius *mut.* belphegor

Spirifer eriensis Grabau *var.* Grabau

5186 $\frac{8342}{3}$ HYPOTYPE Spirifer eriensis Grabau var. Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1043, fig.7a, b.
Manlius limestone
Becraft mountain, Columbia co. N. Y.
A. W. Grabau, coll. 1902

5187 $\frac{8342}{4}$ HYPOTYPE Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1043, fig.7c.
Manlius limestone Becraft mountain, N. Y.
A. W. Grabau, coll. 1902

5188 $\frac{8342}{5}$ HYPOTYPE Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1043, fig.7d.
Manlius limestone Becraft mountain, N. Y.
A. W. Grabau, coll. 1902

Spirifer corallinensis Grabau

5189 $\frac{8367}{1}$ HYPOTYPE Spirifer corallinensis Grabau. Geological society of America bulletin. 1900. 11:352.
Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1042, fig.6.
Manlius limestone Becraft mountain, N. Y.
A. W. Grabau, coll. 1902

Spirifer fimbriatus Conrad *mut.* **pygmaeus** Loomis

5190 $\frac{8368}{1}$ TYPE Spirifer fimbriatus Conrad mut. pygmaeus Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.901, pl.2, fig.8, 9.
Tully pyrite Canandaigua lake, N. Y.
D. D. Luther, coll.

Spirifer fimbriatus Conrad *mut.* **simplicissimus** Loomis

5191 $\frac{8369}{1}$ TYPE Spirifer fimbriatus mut. simplicissimus Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.901, pl.3, fig.1, 2.
Tully pyrite Canandaigua lake, N. Y.
D. D. Luther, coll.

Spirifer granulosus Conrad *mut.* **pluto** Clarke

5192 $\frac{8370}{1}$ HYPOTYPE Spirifer pluto Clarke. United States geological survey bulletin 16. 1885. p.31.

Spirifer granulosus Conrad mut. pluto Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.3, fig.7, 8.

Tully pyrite Canandaigua lake, N. Y.

D. D. Luther, coll.

Spirifer medialis Hall *mut.* **pygmaeus** Loomis

5193 $\frac{8371}{1}$ TYPE Spirifer medialis Hall mut. pygmaeus Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.902, pl.3, fig.9, 10.

Tully pyrite Canandaigua lake, N. Y.

D. D. Luther, coll.

Spirifer mucronatus Conrad *mut.* **hecate** Clarke

5194 $\frac{8372}{1}$ HYPOTYPE Leiorhynchus? hecate Clarke. United States geological survey bulletin 16. 1885. p.31.

Spirifer mucronatus Conrad mut. hecate Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.3, fig.13–15.

Tully pyrite Moscow, Livingston co. N. Y.

D. D. Luther, coll.

Spirifer pluto *see* Spirifer granulosus *mut.* pluto

Spirifer tullius Conrad *mut.* **belphegor** Clarke

5195 $\frac{8373}{1}$ HYPOTYPE Spirifer belphegor Clarke. United States geological survey bulletin 16. 1885. p.30.

Spirifer tullius Conrad mut. belphegor Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.3, fig.3, 4.

Tully pyrite Canandaigua lake, N. Y.

D. D. Luther, coll.

Spirifer vanuxemi Hall

5196 $\frac{8374}{1}$ HYPOTYPE Spirifer vanuxemi Hall. Paleontology of New York. 1859. 3:198.

Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1041, fig.5a.

Manlius limestone

Becraft mountain, Columbia co. N. Y.

A. W. Grabau, coll. 1902

5197 $\frac{8374}{2}$ HYPOTYPE Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1041, fig.5b.

Manlius limestone — Becraft mountain, N. Y.
A. W. Grabau, coll. 1902

STROPHALOSIA King

Strophalosia truncata Hall *mut.* **pygmaea** Loomis

5198 $\frac{8395}{1}$ TYPE Strophalosia truncata Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.906, pl.2, fig. 10.

Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

5199 $\frac{8395}{2}$ TYPE Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.2, fig.12.

Tully pyrite — Canandaigua lake, N. Y.

TRIGERIA Bayle

Trigeria lepida Hall *mut.* **pygmaea** Loomis

5200 $\frac{8501}{1}$ TYPE Trigeria lepida Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.907, pl.3, fig.11.

Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

TROPIDOLEPTUS Hall

Tropidoleptus carinatus Conrad *mut.* **pygmaeus** Loomis

5201 $\frac{8531}{1}$ TYPE Tropidoleptus carinatus Conrad mut. pygmaeus Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.906, pl.3, fig.12.

Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

WHITFIELDELLA Hall & Clarke

Whitfieldella *cf.* **nitida** Hall

5202 $\frac{8563}{6}$ HYPOTYPE Whitfieldella cf. nitida Grabau. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1051, fig.10a-c.

Manlius limestone
Becraft mountain, Columbia co. N. Y.
A. W. Grabau, coll. 1902

LAMELLIBRANCHIATA

ACTINOPTERIA Hall

Actinopteria sola Clarke

5203 $\frac{9020}{1}$ TYPE: PLASTOTYPE Actinopteria sola Clarke. New York state museum memoir 6. 1903. p.263, pl.20, fig. 20.
Portage (Naples) beds
Cashaqua creek, Livingston co. N. Y.
J. M. Clarke, purchase

Astarte subtextilis *see* Euthydesma subtextile

Avicula dispar *see* Loxopteria dispar

Avicula fragilis *see* Pterochaenia fragilis

BUCHIOLA Barrande

Buchiola? (Puella?) sp.

5204 $\frac{9081}{1}$ TYPE Buchiola? (Puella?) sp. New York state museum memoir 6. 1903. pl.10, fig.17.
Portage (Naples) beds Naples, Ontario co. N. Y.
J. M. Clarke, donor

Buchiola angolensis Clarke

5205 $\frac{9082}{1}$ TYPE: PLASTOTYPE Buchiola angolensis Clarke. New York state museum memoir 6. 1903. p.300, pl.10, fig.29.
Portage (Naples) beds
Farnham creek, near Angola N. Y.
D. D. Luther, coll. 1897

5206 $\frac{9082}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.30.
Portage (Naples) beds
Farnham creek, near Angola N. Y.
J. M. Clarke, coll. 1898

5207 $\frac{9082}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.31.
Portage (Naples) beds
Farnham creek, near Angola N. Y.
D. D. Luther, coll. 1897

5208 $\frac{9082}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.32.
Portage (Naples) beds Big Sister creek, Angola N. Y.
D. D. Luther, coll. 1897

5209 $\frac{9082}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.33.
Portage (Naples) beds
Smith's Mills, Chautauqua co. N. Y.
D. D. Luther, coll. 1902

Buchiola conversa Clarke

5210 $\frac{9083}{1}$ TYPE Buchiola conversa Clarke. New York state museum memoir 6. 1903. p.300, pl.10, fig.20.
Portage (Naples) beds Farnham creek, Angola N. Y.
J. M. Clarke, coll. 1898

5211 $\frac{9083}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.21.
Portage (Naples) beds Angola, Erie co. N. Y.
J. M. Clarke, donor

5212 $\frac{9083}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.22.
Portage (Naples) beds Big Sister creek, Angola N. Y.
J. M. Clarke, coll. 1898

Buchiola *cf.* eifelensis Beushausen

5213 $\frac{9084}{1}$ HYPOTYPE Buchiola *cf.* eifelensis Clarke. New York state museum memoir 6. 1903. pl.11, fig.3.
Lower Upper Devonic Büdesheim, Germany

Buchiola halli Clarke

5214 $\frac{9085}{1}$ TYPE Buchiola halli Clarke. New York state museum memoir 6. 1903. p.301, pl.10, fig.16.
Hamilton shale
Near Norton's landing, Cayuga lake, N. Y.
H. H. Smith, coll. 1871

Buchiola (?) livoniae Clarke

5215 $\frac{9086}{1}$ TYPE Buchiola (?) livoniae Clarke. New York state museum memoir 6. 1903. p.299, pl.11, fig.1.
Genesee beds (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, coll. 1899

5216 $\frac{9086}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.2.
Genesee beds (Genundewa limestone)
Livonia salt shaft, Livingston co. N. Y.
D. D. Luther, coll. 1891

Buchiola lupina Clarke

5217 $\frac{9087}{1}$ TYPE Buchiola lupina Clarke. New York state museum memoir 6. 1903. p.301, pl.10, fig.34.

Portage (Gardeau) beds

Wolf creek, Genesee valley, Wyoming co. N. Y.

D. D. Luther, coll. 1897

5218 $\frac{9087}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.35.

Portage (Gardeau) beds

Mouth of Wolf creek, Wyoming co. N. Y.

D. D. Luther, coll. 1897

5219 $\frac{9087}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.36.

Portage (Gardeau) beds

Mouth of Wolf creek, Wyoming co. N. Y.

D. D. Luther, coll. 1897

Buchiola *cf.* **prümiensis** Steininger (sp.)

5220 $\frac{9088}{1}$ HYPOTYPE Cardium prumiense Steininger. Geognost. Beschreibung der Eifel. 1853. p.51.

Buchiola cf. prümiensis Clarke. New York state museum memoir 6. 1903. pl.10, fig.18.

Portage (Naples) beds

Big Sister creek at Angola N. Y.

D. D. Luther, coll. 1897

On slab with type of pl.10, fig.19.

5221 $\frac{9088}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.19.

Portage (Naples) beds

Big Sister creek at Angola N. Y.

D. D. Luther, coll. 1897

On slab with type of pl.10, fig.18.

Buchiola retrostriata von Buch

5222 $\frac{9089}{1}$ HYPOTYPE Venericardium retrostriatum von Buch. Ueber Goniatiten. 1832. p.50.

Buchiola retrostriata Clarke. New York state museum memoir 6. 1903. pl.10, fig.1.

Portage (Naples) beds Naples, Ontario co. N. Y.

J. M. Clarke, donor

5223 $\frac{9089}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.2.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5224 $\frac{9089}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.3.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5225 $\frac{9089}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.4.
Portage (Naples) beds
Near Mt Morris, Livingston co. N. Y.
C. Van Deloo, coll.

5226 $\frac{9089}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.5.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5227 $\frac{9089}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.6.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5228 $\frac{9089}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.7.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5229 $\frac{9089}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.8.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5230 $\frac{9089}{9}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.9.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5231 $\frac{9089}{10}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.10.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5232 $\frac{9089}{11}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.11.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5233 $\frac{9089}{12}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig 12.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5234 $\frac{9089}{13}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.13.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5235 $\frac{9089}{14}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.14.
Genesee shale — Canandaigua lake, N. Y.
J. M. Clarke, coll. 1899

5236 $\frac{9089}{15}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.14.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

Buchiola retrostriata von Buch *mut.* **pygmaea** Loomis

5237 $\frac{9089a}{1}$ TYPE Buchiola retrostriata von Buch mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.911, pl.2, fig.7.
Tully pyrite — Moscow, Livingston co. N. Y.
D. D. Luther, coll.

Buchiola scabrosa Clarke

5238 $\frac{9089b}{1}$ TYPE Buchiola scabrosa Clarke. New York state museum memoir 6. 1903. p. 299, pl.10, fig.25–27.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5239 $\frac{9089b}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.10, fig.28.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

Cardiola clarkei *see* Ontaria clarkei
Cardiola doris *see* Paracardium doris
Cardiola duplicata *see* Praecardium duplicatum

CARDIOMORPHA de Koninck

Cardiomorpha obliquata Clarke

5240 $\frac{9095}{1}$ TYPE: PLASTOTYPE Cardiomorpha obliquata Clarke. New York state museum memoir 6. 1903. pl.9, fig.3.
Portage (Naples) beds
Forestville, Chautauqua co. N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5241 $\frac{9095}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.4,5.
Portage (Naples) beds
Little Canadaway creek, Lake Erie, N. Y.
D. D. Luther, coll. 1897

5242 $\frac{9095}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.6.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5243 $\frac{9095}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.7.
Portage (Naples) beds
Near Smith's Mills, Chautauqua co. N. Y.
D. D. Luther, coll. 1902

Cardium prumiense *see* Buchiola *cf.* prümiensis

Cardium? vetustum *see* Praecardium vetustum

CONOCARDIUM Bronn

Conocardium eboraceum Hall *mut.* **pygmaeum** Loomis

5244 $\frac{9146}{1}$ TYPE Conocardium eboraceum Hall mut. pygmaeum Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.911, pl.2, fig.6.
Tully pyrite Moscow N. Y.
D. D. Luther, coll.

Conocardium gowandense Clarke

5245 $\frac{9147}{1}$ TYPE Conocardium gowandense Clarke. New York state museum memoir 6. 1903. p.310, pl.12, fig. 35, 36.
Portage (Naples) beds
Gowanda, Cattaraugus co. N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

ELASMATIUM Clarke

Elasmatium gowandense Clarke

5246 $\frac{9200}{1}$ TYPE Elasmatium gowandense Clarke. New York state museum memoir 6. 1903. p.294, pl.12, fig.21.
Portage (Naples) beds Chautauqua county, N. Y.

5247 $\frac{9200}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.22.
Portage (Naples) beds Chautauqua county, N. Y.

5248 $\frac{9200}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.23.
Portage (Naples) beds Chautauqua county, N. Y.

5249 $\frac{9200}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig 24.
Portage (Naples) beds Chautauqua county, N. Y.

5250 $\frac{9200}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.25.
Portage (Naples) beds Gowanda forks of Cattaraugus creek, Chautauqua co. N. Y.
D. D. Luther, coll. 1897

5251 $\frac{9200}{6}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.26.
Portage (Naples) beds
Gowanda forks of Cattaraugus creek, N. Y.
D. D. Luther, coll. 1897

5252 $\frac{9200}{7}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.27.
Portage (Naples) beds
Gowanda forks of Cattaraugus creek, N. Y.
D. D. Luther, coll. 1897

5253 $\frac{9200}{8}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.28.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5254 $\frac{9200}{9}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.29.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

EUTHYDESMA Hall

Euthydesma subtextile Hall

5255 $\frac{9215}{3}$ HYPOTYPE Astarte subtextilis Hall. Geology of New York; report on the 4th district. 1843. p.245.
Euthydesma subtextile Clarke. New York state museum memoir 6. 1903. pl.9, fig.8.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5256 $\frac{9215}{4}$ HYPOTYPE: HYPOPLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.9.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5257 $\frac{9215}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.10.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5258 $\frac{9215}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.11, 12.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5259 $\frac{9215}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.13.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5260 $\frac{9215}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.14.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5261 $\frac{9215}{9}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.15.
Portage (Naples) beds
Forestville, Chautauqua co. N. Y.
D. D. Luther, coll. 1902

5262 $\frac{9215}{10}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.16.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5263 $\frac{9215}{11}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.9, fig.17.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

GRAMMYSIA de Verneuil

Grammysia constricta Hall *mut.* **pygmaea** Loomis

5264 $\frac{9299}{1}$ TYPE Grammysia constricta Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.910, pl.2, fig.1, 2.
Tully pyrite Greigsville, Livingston co. N. Y.
D. D. Luther, coll.

HONEOYEA Clarke

Honeoyea desmata Clarke

5265 $\frac{9299F}{1}$ TYPE: PLASTOTYPE Honeoyea desmata Clarke. New York state museum memoir 6. 1903. p.260, pl.6, fig.23.
Portage (Naples) beds Tannery gully, Naples N.Y.
J. M. Clarke, donor

Honeoyea erinacea Clarke

5266 $\frac{9299Fa}{1}$ TYPE Honeoyea erinacea Clarke. New York state museum memoir 6. 1903. p.256, pl.6, fig.15, 18.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5267 $\frac{9299Fa}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.16, 19.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5268 $\frac{9299Fa}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.17.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5269 $\frac{9299Fa}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.20
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5270 $\frac{9299Fa}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.21.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5271 $\frac{9299Fa}{6}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.22.
Portage (Naples) beds Parrish gully, Naples N. Y.
J. M. Clarke, donor

Honeoyea major Clarke

5272 $\frac{9299Fb}{1}$ TYPE Honeoyea major Clarke. New York state museum memoir 6. 1903. p.258, pl.6, fig.10.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5273 $\frac{9299Fb}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.11.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5274 $\frac{9299Fb}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.12.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5275 $\frac{9299Fb}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.13.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5276 $\frac{9299Fb}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.14.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

Honeoyea simplex Clarke

5277 $\frac{9299Fc}{1}$ TYPE Honeoyea simplex Clarke. New York state museum memoir 6. 1903. p.259, pl.6, fig.1-3.
Genesee beds (Genundewa limestone)
Genundewa, Canandaigua lake, N. Y.
J. M. Clarke, donor

Honeoyea styliophila Clarke

5278 $\frac{9299Fd}{1}$ TYPE Honeoyea styliophila Clarke. New York state museum memoir 6. 1903. p.258, pl.6, fig.4, 5.
Genesee beds (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, donor

5279 $\frac{9299Fd}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.6.
Genesee beds (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, donor

5280 $\frac{9299Fd}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.6, fig.7–9.
Genesee beds (Genundewa limestone)
Canandaigua lake, N. Y.

KOCHIA Frech

K o c h i a (L o x o p t e r i a) l a e v i s *see* Loxopteria laevis

Kochia ungula Clarke

5281 $\frac{9299M}{1}$ TYPE K o c h i a u n g u l a Clarke. New York state museum memoir 6. 1903. p.270, pl.13, fig.1, 2.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5282 $\frac{9299M}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.3.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5283 $\frac{9299M}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.4.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5284 $\frac{9299M}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.5.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5285 $\frac{9299M}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.6.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5286 $\frac{9299M}{6}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.7.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5287 $\frac{9299M}{7}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.8.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

LEDA Schumacher

Leda rostellata Hall *mut.* **pygmaea** Loomis

5288 $\frac{9304}{1}$ TYPE Leda rostellata Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.909, pl.1, fig.5.
Tully pyrite — Greigsville, Livingston co. N. Y.
D. D. Luther, coll.

5289 $\frac{9304}{2}$ TYPE Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.1, fig.6.
Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

LEPTODOMUS McCoy

Leptodomus interplicatus Clarke

5290 $\frac{9358}{1}$ TYPE Leptodomus interplicatus Clarke. New York state museum memoir 6. 1903. p.315, pl.12, fig.32.
Portage beds (Hatch shales) — Naples N. Y.
J. M. Clarke, donor

5291 $\frac{9358}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.33.
Portage beds (Hatch shales)
Naples valley, Ontario co. N. Y.
J. M. Clarke, donor

5292 $\frac{9358}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.34.
Portage beds (Hatch shales) — Naples valley N. Y.

Leptodomus multiplex Clarke

5293 $\frac{9358a}{1}$ TYPE Leptodomus multiplex Clarke. New York state museum memoir 6. 1903. p.315, pl.12, fig.30.
Portage beds (Rhinestreet black shales) — Naples N. Y.
J. M. Clarke, donor

LOXOPTERIA Frech

Loxopteria (Sluzka) corrugata Clarke

5294 $\frac{9359}{1}$ TYPE Loxopteria (Sluzka) corrugata Clarke. New York state museum memoir 6. 1903. p.277, pl.14, fig.15.
Portage (Naples) beds — Correll's point, Lake Erie

5295 $\frac{9359}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.18.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5296 $\frac{9359}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.19.
Portage (Naples) beds
Smith's Mills, Chautauqua co. N. Y.
D. D. Luther, coll. 1902

5297 $\frac{9359}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.20.
Portage (Naples) beds
Forestville, Chautauqua co. N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5298 $\frac{9359}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.21.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5299 $\frac{9359}{6}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.22.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke, donor

5300 $\frac{9359}{7}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.23.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5301 $\frac{9359}{8}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.24.
Portage (Naples) beds Forestville N. Y.

5302 $\frac{9359}{9}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.25.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5303 $\frac{9359}{10}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.26.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

Loxopteria dispar Sandberger (sp.)

5304 $\frac{9359a}{1}$ HYPOTYPE *Avicula dispar* Sandberger. Verstein. des rhein. Schichtensyst. in Nassau. p.284.

Loxopteria dispar Clarke. New York state museum memoir 6. 1903. pl.13, fig.9.

Portage (Naples) beds Forestville N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5305 $\frac{9359a}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.10.

Portage (Naples) beds Forestville N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5306 $\frac{9359a}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.11.

Portage (Naples) beds Forestville N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5307 $\frac{9359a}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.12.

Portage (Naples) beds Correll's point, Lake Erie

J. M. Clarke and D. D. Luther, coll. 1898

5308 $\frac{9359a}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.13.

Portage (Naples) beds

Gowanda, Cattaraugus co. N. Y.

J. M. Clarke, donor

5309 $\frac{9559a}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.14.

Portage (Naples) beds Forestville N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5310 $\frac{9359a}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.15.

Portage (Naples) beds Forestville N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5311 $\frac{9359a}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.16.

Portage (Naples) beds Forestville N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5312 $\frac{9359a}{9}$ HYPOTYPE: HYPOPLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.13, fig.16.
Portage (Naples) beds
Walnut creek, Forestville N. Y.
J. M. Clarke, donor

Loxopteria (Sluzka) intumescentis Clarke

5313 $\frac{9359b}{1}$ TYPE Loxopteria (Sluzka) intumescentis Clarke. New York state museum memoir 6. 1903. p.276, pl.14, fig.8.
Portage (Naples) beds Lake Erie shore, Ripley N. Y.
J. M. Clarke, donor

5314 $\frac{9359b}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.9.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke, donor

5315 $\frac{9359b}{3}$ TYPE: PLASTOTYPE New York state museum memoir 6. 1903. pl.14, fig.10.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5316 $\frac{9359b}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.11.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5317 $\frac{9359b}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.12.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5318 $\frac{9359b}{6}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.13, 14.
Portage (Naples) beds
Smith's Mills, Chautauqua co. N. Y.
D. D. Luther, coll. 1902

5319 $\frac{9359b}{7}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.16.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5320 $\frac{93599b}{8}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.17.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Loxopteria laevis Frech

5321 $\frac{93599c}{1}$ HYPOTYPE Kochia (Loxopteria) laevis Frech. Die Devonischen Aviculiden Deutschlands; Abhandl. z. geolog. Specialkarte Preuss. u. d. Thür. St. 1891. v.9, Heft 3, p.76.
Loxopteria laevis Clarke. New York state museum memoir 6. 1903. pl.14, fig.1.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5322 $\frac{93599c}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.2, 3.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5323 $\frac{93599c}{3}$ HYPOTYPE: HYPOPLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.4.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke, donor

5324 $\frac{93599c}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.5.
Portage (Naples) beds Gowanda forks of Cattaraugus creek, Chautauqua co. N. Y.
D. D. Luther, coll. 1897

5325 $\frac{93599c}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.6.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5326 $\frac{93599c}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.14, fig.7.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Loxopteria vasta Clarke

5327 $\frac{93599d}{1}$ TYPE Loxopteria vasta Clarke. New York state museum memoir 6. 1903. p.275, pl.13, fig.18.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

LUNULICARDIUM Münster

Lunulicardium sp. nov. ? Clarke

5328 $\frac{9407}{1}$ TYPE Lunulicardium sp. nov. ? Clarke. New York state museum memoir 6. 1903. p.245, pl.2, fig.19.
Genesee beds (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, donor

Lunulicardium sp. nov. Clarke

5329 $\frac{9408}{1}$ TYPE Lunulicardium sp. nov. Clarke. New York state museum memoir 6. 1903. p.245, pl.2, fig.21.
Portage (Naples) beds
Seneca point, Canandaigua lake, N. Y.
J. M. Clarke, donor

Lunulicardium sp. nov. ? Clarke

5330 $\frac{9409}{1}$ TYPE Lunulicardium sp. nov. ? Clarke. New York state museum memoir 6. 1903. p.246, pl.4, fig.11.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

Lunulicardium (Prochasma) absegmen Clarke

5331 $\frac{9410}{1}$ TYPE Lunulicardium (Prochasma) absegmen Clarke. New York state museum memoir 6. 1903. p.242, pl.3, fig.15.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

Lunulicardium (Pinnopsis) accola Clarke

5332 $\frac{9411}{1}$ TYPE (original and counterpart) Lunulicardium (Pinnopsis) accola Clarke. New York state museum memoir 6. 1903. p.233, pl.4, fig.12.
Portage (Naples) beds West Falls, Erie co. N. Y.
D. D. Luther, coll. 1897

5333 $\frac{9411}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.13.
Portage (Naples) beds Forestville N. Y.
D. D. Luther, coll. 1902

Lunulicardium acutirostrum *see* Lunulicardium (Pinnopsis) acutirostrum

Lunulicardium (Pinnopsis) acutirostrum Hall

5334 $\frac{9412}{1}$ HYPOTYPE: HYPOPLASTOTYPE Pinnopsis acutirostra Hall. Geology of New York; report on the 4th district. 1843. p.244.

Lunulicardium (Pinnopsis) acutirostrum Clarke. New York state museum memoir 6. 1903. pl.1, fig.1.

Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5335 $\frac{9412}{2}$ HYPOTYPE Lunulicardium acutirostrum Hall. Paleontology of New York. 1883. v.5, pt 1, plates and explanations, pl.71, fig.31.

Lunulicardium ornatum Hall. Paleontology of New York. 1885. v.5, pt 1, pl.71, fig.31.

Lunulicardium (Pinnopsis) acutirostrum Clarke. New York state museum memoir 6. 1903. pl.1, fig.2.

? Chemung beds Elmira, Chemung co. N. Y.
J. W. Hall and C. VanDeloo, coll. 1866

5336 $\frac{9412}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.1, fig.3.

Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5337 $\frac{9412}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.1, fig.4, 5.

Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5338 $\frac{9412}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.1, fig.6.

Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5339 $\frac{9412}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.10.

Portage (Naples) beds Naples N. Y.

Lunulicardium beushauseni Clarke

5340 $\frac{9413}{1}$ TYPE Lunulicardium beushauseni Clarke. New York state museum memoir 6. 1903. pl.3, fig.12.

Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5341 $\frac{9413}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.3, fig.13.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5342 $\frac{9413}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.15.
Portage (Naples) beds Fox's point, Lake Erie, N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Lunulicardium bickense *see* Lunulicardium (Prochasma) bickense

Lunulicardium (Prochasma) bickense Holzapfel

5343 $\frac{9414}{1}$ HYPOTYPE Lunulicardium bickense Holzapfel. Die Goniatitenkalke von Adorf; Palaeontographica. 1882. 28:256.
Lunulicardium (Prochasma) bickense Clarke. New York state museum memoir 6. 1903. pl.3, fig.3.
Portage (Naples) beds
Farnham creek, Angola N. Y.
J. M. Clarke, coll. 1898

5344 $\frac{9414}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.3, fig.4.
Portage (Naples) beds
Lower Portage falls, Genesee river, N. Y.
D. D. Luther, coll. 1897

5345 $\frac{9414}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.3, fig.5.
Portage (Naples) beds
Lower Portage falls, Genesee river, N. Y.
D. D. Luther, coll. 1897

5346 $\frac{9414}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.3, fig.11.
Portage (Naples) beds
Johnson's falls, near Strykersville N. Y.
D. D. Luther, coll. 1897

Lunulicardium (Chaenocardiola) clymeniae Clarke

5347 $\frac{9415}{1}$ TYPE Lunulicardium (Chaenocardiola) clymeniae Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1231, fig.1.

Clarke. New York state museum memoir 6. 1903. p.234; p.224, fig. 3.

Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5348 $\frac{9415}{2}$ TYPE Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1231, fig.2–4.

Clarke. New York state museum memoir 6. 1903. p.224, fig.4–6.

Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5349 $\frac{9415}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.2, fig.1–5.

Portage (Naples) beds
Whetstone gully, near Livonia N. Y.
J. M. Clarke, donor

5350 $\frac{9415}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.2, fig.6 (2 pieces).

Portage (Naples) beds
Brigg's gully, Honeoye lake, N. Y.
J. M. Clarke, donor

Lunulicardium encrinitum Clarke

5351 $\frac{9416}{1}$ TYPE Lunulicardium encrinitum Clarke. New York state museum memoir 6. 1903. p.239, pl.2, fig.20.

Portage (Naples) beds
Blacksmith gully, Bristol N. Y.
J. M. Clarke, donor

Lunulicardium (Prochasma) enode Clarke

5352 $\frac{9417}{1}$ TYPE Lunulicardium (Prochasma) enode Clarke. New York state museum memoir 6. 1903. p.242, pl.3, fig.14.

Portage (Naples) beds
Lower Portage falls, Genesee river, N. Y.
J. M. Clarke, donor

Lunulicardium (Chaenocardiola) eriense Clarke

5353 $\frac{9418}{1}$ TYPE Lunulicardium (Chaenocardiola) eriense Clarke. New York state museum memoir 6. 1903. p.235, pl.4, fig.3.
Portage (Naples) beds
Forestville, Chautauqua co. N. Y.
D. D. Luther, coll. 1902

5354 $\frac{9418}{2}$ TYPE Clarke. New York state museum memoir 6. 1903 pl.4, fig.4.
Portage (Naples) beds Forestville N. Y.
D. D. Luther, coll. 1902
On slab with type of pl.4, fig.6.

5355 $\frac{9418}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.5.
Portage (Naples) beds
Correll's point, Lake Erie, N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5356 $\frac{9418}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.6.
Portage (Naples) beds Forestville N. Y.
D. D. Luther, coll. 1902
On slab with type of pl.4, fig.4.

Lunulicardium finitimum Clarke

5357 $\frac{9419}{1}$ TYPE Lunulicardium finitimum Clarke. New York state museum memoir 6. 1903. p.238, pl.2, fig.17.
Portage (Naples) beds Parrish gully, Naples N. Y.
J. M. Clarke, donor

5358 $\frac{9419}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.2, fig.18.
Portage (Naples) beds Parrish gully, Naples N. Y.
J. M. Clarke, donor

Lunulicardium fragile *see* Pterochaenia fragilis

Lunulicardium (Chaenocardiola) furcatum Clarke

5359 $\frac{9419a}{1}$ TYPE Lunulicardium (Chaenocardiola) furcatum Clarke. New York state museum memoir 6. 1903. p.236, pl 4, fig.7.
Portage (Naples) beds
Correll's point, Lake Erie, N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Lunulicardium (Chaenocardiola) hemicardioides Clarke

5360 $\frac{9419b}{1}$ TYPE Lunulicardium (Chaenocardiola) hemicardioides Clarke. New York state museum memoir 6. 1903. p.235, pl.2, fig.11, 12.
Portage (Naples) beds Parrish gully, Naples N. Y.
J. M. Clarke, donor

5361 $\frac{9419b}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.2, fig.13, 14.
Portage (Naples) beds Parrish gully, Naples N. Y.
J. M. Clarke, donor

5362 $\frac{9419b}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.2, fig.15.
Genesee beds (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, donor

5363 $\frac{9419b}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.2, fig.16.
Genesee beds (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, donor

Lunulicardium *cf.* **inflatum** Holzapfel

5364 $\frac{9419c}{1}$ HYPOTYPE Lunulicardium cf. inflatum Holzapfel. Die Goniatitenkalke von Adorf; Palaeontographica. 1882. 28:33.
Clarke. New York state museum memoir 6. 1903. pl.3, fig.16.
Intumescens zone Martenberg, Westphalia

Lunulicardium (Pinnopsis) libum Clarke

5365 $\frac{9419d}{1}$ TYPE Lunulicardium (Pinnopsis) libum Clarke. New York state museum memoir 6. 1903. p.232, pl.2, fig.10.
Portage (Naples) beds Fox's point, Lake Erie, N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5366 $\frac{9419d}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.1.
Portage (Naples) beds Fox's point, Lake Erie, N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5367 $\frac{9419d}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.2.

Portage (Naples) beds Fox's point, Lake Erie, N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

Lunulicardium mülleri Holzapfel

5368 $\frac{9419e}{1}$ HYPOTYPE Lunulicardium mülleri Holzapfel. Die Goniatitenkalke von Adorf; Palaeontographica. 1882. p.32.

Clarke. New York state museum memoir 6. 1903. pl.3, fig.1,2.

Intumescens zone Martenberg, Westphalia

J. M. Clarke, donor

Lunulicardium ornatum *see* Lunulicardium (Pinnopsis) acutirostrum

Lunulicardium (Pinnopsis) ornatum Hall

5369 $\frac{9405}{3}$ HYPOTYPE Pinnopsis ornatus Hall. Geology of New York; report on the 4th district. 1843. p.244.

Lunulicardium (Pinnopsis) ornatum Clarke. New York state museum memoir 6. 1903. pl.1, fig.8.

Portage (Naples) beds Naples N. Y.

J. M. Clarke, donor

5370 $\frac{9405}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.1, fig.9.

Portage (Naples) beds Naples N. Y.

J. M. Clarke, donor

5371 $\frac{9405}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.1, fig.10.

Portage (Naples) beds Naples N. Y.

J. M. Clarke, donor

5372 $\frac{9405}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.1, fig.11.

Portage (Naples) beds Naples N. Y.

J. M. Clarke, donor

5373 $\frac{9405}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.1, fig.12,13.

Portage (Naples) beds

Belknap's gully, 2 miles north of Branchport N. Y.

J. M. Clarke, coll. 1895

5374 $\frac{9405}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.1, fig.14.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

Lunulicardium (Prochasma) parunculus Clarke

5375 $\frac{9419f}{1}$ TYPE: PLASTOTYPE *Lunulicardium (Prochasma) parunculus* Clarke. New York state museum memoir 6. 1903. p.243, pl.3, fig.17.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5376 $\frac{9419f}{2}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.3, fig.18.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5377 $\frac{9419f}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.3, fig.19.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5378 $\frac{9419f}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.14.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

Lunulicardium pilosum Clarke

5379 $\frac{9419g}{1}$ TYPE *Lunulicardium pilosum* Clarke. New York state museum memoir 6. 1903. p.239, pl.2, fig.23.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5380 $\frac{9419g}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.2, fig.24.
Portage (Naples) beds — Parrish gully, Naples N. Y.
J. M. Clarke, donor

5381 $\frac{9419g}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.8.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5382 $\frac{9419g}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.9.
Portage (Naples) beds — Pike's creek, Erie co. N. Y.
D. D. Luther, coll. 1902

Lunulicardium sodale Clarke

5383 $\frac{94119h}{1}$ TYPE Lunulicardium sodale Clarke. New York state museum memoir 6. 1903. p.238, pl.2, fig. 22.

Portage (Naples) beds

Base of Hatch hill, Naples N. Y.

J. M. Clarke, donor

Lunulicardium suppar Clarke

5384 $\frac{94119i}{1}$ TYPE Lunulicardium suppar Clarke. New York state museum memoir 6. 1903. p. 244, pl.3, fig.6.

Portage (Naples) beds

Johnson's falls, near Strykersville N. Y.

J. M. Clarke, donor

5385 $\frac{94119i}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.3, fig.7.

Portage (Naples) beds

Johnson's falls, near Strykersville N. Y.

J. M. Clarke, donor

5386 $\frac{94119i}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.3, fig. 8,9.

Portage (Naples) beds

Johnson's falls, near Strykersville N. Y.

D. D. Luther, coll. 1897

5387 $\frac{94119i}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.3, fig.10.

Portage (Naples) beds

Lower Portage falls, Genesee river, N. Y.

J. M. Clarke, donor

Lunulicardium ? (Opisthocoelus ?) transversale Clarke

5388 $\frac{94119j}{1}$ TYPE Lunulicardium? (Opisthocoelus?) transversale Clarke. New York state museum memoir 6. 1903. p.246, pl.4, fig.16.

Portage (Naples) beds Ithaca, Tompkins co. N. Y.

C. Van Deloo, coll. 1874

Lunulicardium velatum Clarke

5389 $\frac{94119k}{1}$ TYPE Lunulicardium velatum Clarke. New York state museum memoir 6. 1903. p.237, pl.2, fig.7.

Portage (Naples) beds

Base of Hatch hill, Naples N. Y.

J. M. Clarke, donor

5390 $\frac{9419k}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.2, fig.8.
Portage (Naples) beds Parrish gully, Naples N. Y.
J. M. Clarke, donor

5391 $\frac{9419k}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.2, fig.9.
Portage (Naples) beds
Base of Hatch hill, Naples N. Y.
J. M. Clarke, donor

Lunulicardium (Pinnopsis) wiscoyense Clarke

5392 $\frac{9419l}{1}$ TYPE Lunulicardium (Pinnopsis) wiscoyense Clarke. New York state museum memoir 6. 1903. p.233, pl.1, fig.7.
Portage (Naples) beds Wiscoy creek, Wiscoy above the bridge, Allegany co. N. Y.
D. D. Luther, coll. 1897

MODIELLA Hall

Modiella sp. ? Clarke

5393 $\frac{9481}{1}$ TYPE Modiella sp. ? Clarke. New York state museum memoir 6. 1903. p.316, pl.12, fig.31.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

NUCULA Lamarck

Nucula corbuliformis Hall *mut.* **pygmaea** Loomis

5394 $\frac{9577}{1}$ TYPE Nucula corbuliformis Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.908, pl.1, fig. 10, 11.
Tully pyrite Livonia salt shaft, Livingston co. N. Y.
D. D. Luther, coll.

Nucula lirata Hall *mut.* **pygmaea** Loomis

5395 $\frac{9578}{1}$ TYPE Nucula lirata Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.908, pl.1, fig.14, 15.
Tully pyrite Livonia salt shaft, Livingston co. N. Y.
D. D. Luther, coll.

Nucula varicosa Hall *mut.* **pygmaea** Loomis

5396 $\frac{9579}{1}$ TYPE Nucula varicosa Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.908, pl.2, fig.3, 4.

Tully pyrite — Greigsville N. Y.

D. D. Luther, coll.

NUCULITES Conrad

Nuculites constricta *see* Palaeoneilo constricta

Nuculites oblongatus Conrad *mut.* **pygmaeus** Loomis

5397 $\frac{9584}{1}$ TYPE Nuculites oblongatus Conrad mut. pygmaeus Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p. 909, pl.1, fig.7.

Tully pyrite — Moscow, Livingston co. N. Y.

D. D. Luther, coll.

Nuculites triqueter Conrad *mut.* **pygmaea** Loomis

5398 $\frac{9585}{1}$ TYPE Nuculites triqueter Conrad mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.909, pl.1, figs.16, 17.

Tully pyrite — Moscow N. Y.

D. D. Luther, coll.

ONTARIA Clarke

Ontaria sp.? Clarke

5399 $\frac{9595}{1}$ TYPE Ontaria sp.? Clarke. New York state museum memoir 6. 1903. pl.8, fig.27.

Portage (Naples) beds — Naples N. Y.

J. M. Clarke, donor

Ontaria accincta Clarke

5400 $\frac{9596}{1}$ TYPE Ontaria accincta Clarke. New York state museum memoir 6. 1903. p.288, pl.8, fig.22.

Portage (Naples) beds

Cashaqua creek, Livingston co. N. Y.

D. D. Luther, coll. 1897

5401 $\frac{9596}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl 8, fig.23.

Portage (Naples) beds — Cashaqua creek N. Y.

D. D. Luther, coll. 1897

5402 $\frac{9596}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.24.
Portage (Naples) beds Cashaqua creek N. Y.
D. D. Luther, coll. 1897

5403 $\frac{9596}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.25.
Portage (Naples) beds Cashaqua creek N. Y.
D. D. Luther, coll. 1897

Ontaria affiliata Clarke

5404 $\frac{9597}{1}$ TYPE Ontaria affiliata Clarke. New York state museum memoir 6. 1903. p.290, pl.7, fig.21, 22.
Portage (Naples) beds Naples, Ontario co. N. Y.
J. M. Clarke, donor

Ontaria clarkei Beushausen (sp.)

5405 $\frac{9598}{1}$ HYPOTYPE Cardiola clarkei Beushausen. Abh. der Königl.-Preuss. Geol. Landesanst. N. F. 1885. Heft 17, p.347.
Ontaria clarkei Clarke. New York state museum memoir 6. 1903. pl.7, fig.10.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5406 $\frac{9598}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.11.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5407 $\frac{9598}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.12.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5408 $\frac{9598}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.13.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5409 $\frac{9598}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.14.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5410 $\frac{9598}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.15.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor
On slab with type of pl.7, fig.17.

5411 $\frac{9598}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.16.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5412 $\frac{9598}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.17.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor
On slab with type of pl.7, fig.15.

5413 $\frac{9598}{9}$ HYPOTYPE Clarke. New York state museum memoir 6, 1903. pl.7, fig.18.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5414 $\frac{9598}{10}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.19.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5415 $\frac{9598}{11}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.20.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

Ontaria concentrica von Buch (sp.)

5416 $\frac{9599}{1}$ HYPOTYPE Orbicula concentrica von Buch. Ueber Goniatiten. 1832. p.50.
Ontaria concentrica Clarke. New York state museum memoir 6. 1903. pl.8, fig.26.
Portage (Naples) beds
Correll's point, Lake Erie, N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Ontaria halli Clarke

5417 $\frac{9599a}{1}$ TYPE Ontaria halli Clarke. New York state museum memoir 6. 1903. p.290, pl.7, fig.23.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5418 $\frac{9599a}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl 7, fig.24, 24A.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5419 $\frac{9599a}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.28.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

Ontaria pontiaca Clarke

5420 $\frac{9599b}{1}$ TYPE: PLASTOTYPE Ontaria pontiaca Clarke. New York state museum memoir 6. 1903. pl.8, fig. 21.
Portage (Naples) beds Pontiac, Erie co. N. Y.

Ontaria suborbicularis Hall (sp.)

5421 $\frac{9599c}{1}$ HYPOTYPE Ungulina suborbicularis Hall. Geology of New York; report on the 4th district. 1843. p.243.
Ontaria suborbicularis Clarke. New York state museum memoir 6. 1903. pl.8, fig.1.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5422 $\frac{9599c}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.2.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5423 $\frac{9599c}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.3.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5424 $\frac{9599c}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.4.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5425 $\frac{9599c}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.7.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5426 $\frac{9599c}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.11.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5427 $\frac{9599c}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.12.
Portage (Naples) beds Attica, Wyoming co. N. Y.
D. D. Luther, coll. 1897

5428 $\frac{9599c}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.13.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5429 $\frac{9599c}{9}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.14.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5430 $\frac{9599c}{10}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.15.
Portage (Naples) beds Parrish gully, Naples N. Y.
J. M. Clarke, donor

5431 $\frac{9599}{11}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.16.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5432 $\frac{9599c}{12}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.17.
Portage (Naples) beds Naples N. Y.

5433 $\frac{9599c}{13}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.18.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5434 $\frac{9599c}{14}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.19.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5435 $\frac{9599c}{15}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.8, fig.20.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

PALAEONEILO Hall

Palaeoneilo brevicula Clarke

5436 $\frac{9645}{1}$ TYPE Palaeoneilo brevicula Clarke. New York state museum memoir 6. 1903. p.313, pl.15, fig.16.
Portage (Naples) beds Gowanda forks of Cattaraugus creek, Cattaraugus co. N. Y.
D. D. Luther, coll. 1897

Palaeoneilo constricta Conrad (sp.)

5437 $\frac{9634}{6}$ HYPOTYPE Nuculites constricta Conrad. Journal of the Academy of natural sciences of Philadelphia. 1842. 8: 249.

Palaeoneilo constricta Clarke. New York state museum memoir 6. 1903. pl.15, fig.9.

Portage (Naples) beds — Correll's point, Lake Erie

J. M. Clarke and D. D. Luther, coll. 1898

5438 $\frac{9634}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.10.

Portage (Naples) beds — Correll's point, Lake Erie

J. M. Clarke and D. D. Luther, coll. 1898

5439 $\frac{9634}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.11.

Portage (Naples) beds — Correll's point, Lake Erie

J. M. Clarke and D. D. Luther, coll. 1898

5440 $\frac{9634}{9}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.13.

Portage (Naples) beds — Correll's point, Lake Erie

J. M. Clarke and D. D. Luther, coll. 1898

Palaeoneilo constricta Conrad *mut.* pygmaea Loomis

5441 $\frac{9646}{1}$ TYPE Palaeoneilo constricta Conrad mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.910, pl.1, fig.12, 13.

Tully pyrite — Moscow, Livingston co. N. Y.

D. D. Luther, coll.

Palaeoneilo linguata Clarke

5442 $\frac{9647}{1}$ TYPE Palaeoneilo linguata Clarke. New York state museum memoir 6. 1903. p.314, pl.15, fig.17.

Portage (Naples) beds

Forestville, Chautauqua co. N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5443 $\frac{9647}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.18.

Portage (Naples) beds — Forestville N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5444 $\frac{9647}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.20.

Portage (Naples) beds — Forestville N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5445 $\frac{9647}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.21.
Portage (Naples) beds — Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5446 $\frac{9647}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig 22.
Portage (Naples) beds — Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Palaeoneilo muricata Clarke

5447 $\frac{9648}{1}$ TYPE Palaeoneilo muricata Clarke. New York state museum memoir 6. 1903. p.312, pl.15, fig.14, 15.
Portage (Naples) beds — Honeoye lake N. Y.
J. M. Clarke, donor

Palaeoneilo petila Clarke

5448 $\frac{9649}{1}$ TYPE Palaeoneilo petila Clarke. New York state museum memoir 6. 1903. p.311, pl.15, fig.1.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5449 $\frac{9649}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.2.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5450 $\frac{9649}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.3–5.
Portage (Naples) beds — Honeoye lake N. Y.
J. M. Clarke, donor

5451 $\frac{9649}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.6, 7.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5452 $\frac{9549}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.15, fig.8.
Portage (Naples) beds — Pontiac, Erie co. N. Y.

Palaeoneilo plana Hall *mut.* **pygmaea** Loomis

5453 $\frac{9649a}{1}$ TYPE Palaeoneilo plana Hall mut. pygmaea Loomis. New York state museum memoir 6. 1903. p.909, pl.1, fig.8, 9.
Tully pyrite — Livonia salt shaft, Livingston co. N. Y.
D. D. Luther, coll.

PARACARDIUM Barrande

Paracardium delicatulum Clarke

5454 $\frac{9669}{1}$ TYPE Paracardium delicatulum Clarke. New York state museum memoir 6. 1903. p.304, pl.11, fig.4.
Genesee shales (Genundewa limestone)
Canandaigua lake N. Y.

Paracardium doris Hall

5455 $\frac{9669a}{1}$ HYPOTYPE Cardiola doris Hall. Paleontology of New York. 1883. v.5, pt1, plates and explanations, pl.70, fig.10, 11.
Paracardium doris Clarke. New York state museum memoir 6. 1903. pl.11, fig.5.
Portage (Naples) beds Honeoye lake N. Y.
J. M. Clarke, donor

5456 $\frac{9669a}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.6.
Portage (Naples) beds Honeoye lake N. Y.
J. M. Clarke, donor

5457 $\frac{9669a}{3}$ HYPOTYPE Clarke. New York state museum memoir 6 1903. pl.11, fig.7.
Portage (Naples) beds Rock Stream, Yates co. N. Y.
J. M. Clarke, donor

5458 $\frac{9669a}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.8.
Portage (Naples) beds Rock Stream N. Y.
J. M. Clarke, donor

5459 $\frac{9669a}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.9.
Portage (Naples) beds Rock Stream N. Y.
J. M. Clarke, donor

PARACYCLAS Hall

Paracyclas lirata Conrad *mut.* pygmaea Loomis

5460 $\frac{9676}{1}$ TYPE Paracyclas lirata Conrad mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.910, pl.1, fig.2, 3.
Tully pyrite Livonia salt shaft, Livingston co. N. Y.
D. D. Luther, coll.

PARAPTYX Clarke

Paraptyx ontario Clarke

5461 $\frac{9678}{1}$ TYPE Paraptyx ontario Clarke. New York state museum memoir 6. 1903. p.262, pl.7, fig.1.
Portage (Naples) beds Naples, Ontario co. N. Y.
J. M. Clarke, donor

5462 $\frac{9678}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.2.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5463 $\frac{9678}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.3.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5464 $\frac{9678}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.4.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5465 $\frac{9678}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.5.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5466 $\frac{9678}{6}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.6, 7.
Portage (Naples) beds Honeoye lake N. Y.
J. M. Clarke, donor

5467 $\frac{9678}{7}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.8.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5468 $\frac{9678}{8}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.7, fig.9.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

Pinnopsis acutirostra *see* Lunulicardium (Pinnopsis) acutirostrum

Pinnopsis ornatus *see* Lunulicardium (Pinnopsis) ornatum

POSIDONIA Bronn

Posidonia attica Williams (sp.)

5469 $\frac{9710}{1}$ HYPOTYPE Pterinopecten? atticus Williams. United States geological survey bulletin 41. 1887. p.35.

Posidonia attica Clarke. New York state museum memoir 6. 1903. pl.12, fig 10.

Portage (Naples) beds

Pogue's hill, Dansville, Livingston co. N. Y.

J. M. Clarke, donor

On slab with types of pl.12, fig.11, 14.

5470 $\frac{9710}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.11.

Portage (Naples) beds Pogue's hill, Dansville N. Y.

J. M. Clarke, donor

On slab with types of pl. 12, fig. 10, 14.

5471 $\frac{9710}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.12.

Portage (Naples) beds Pogue's hill, Dansville N. Y.

D. D. Luther, coll. 1897

5472 $\frac{9710}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.13.

Portage (Naples) beds

Portage falls, Genesee river N. Y.

D. D. Luther, coll. 1897

5473 $\frac{9710}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.14.

Portage (Naples) beds Pogue's hill, Dansville N. Y.

J. M. Clarke, donor

On slab with types of pl. 12, fig. 10, 11.

5474 $\frac{9710}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.15.

Portage (Naples) beds Pogue's hill, Dansville N. Y.

J. M. Clarke, donor

Posidonia mesacostalis Williams (sp.)

5475 $\frac{9711}{1}$ HYPOTYPE Ptychopteria? mesacostalis Williams. United States geological survey bulletin 41. 1887. p.35.

Posidonia mesacostalis Clarke. New York state museum memoir 6. 1903. pl.12, fig.1.

Portage (Naples) beds

Johnson's falls, near Strykersville N. Y.

D. D. Luther, coll. 1897

On slab with type of pl. 12, fig. 5.

5476 $\frac{9711}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.2.

Portage (Naples) beds

Johnson's falls, near Strykersville N. Y.

D. D. Luther, coll. 1897

5477 $\frac{9711}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.3.

Portage (Naples) beds

Johnson's falls, near Strykersville N. Y.

D. D. Luther, coll. 1897

5478 $\frac{9711}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.4.

Portage (Naples) bed

Johnson's falls, near Strykersville N. Y.

D. D. Luther, coll. 1897

5479 $\frac{9711}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.5.

Portage (Naples) beds

Johnson's falls, near Strykersville N. Y.

D. D. Luther, coll. 1897

On slab with type of pl.12, fig.1.

5480 $\frac{9711}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.6.

Portage (Naples) beds

Varysburg, Wyoming co. N. Y.

D. D. Luther, coll. 1897

5481 $\frac{9711}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.7.

Portage (Naples) beds

Big Sister creek, Angola N. Y.

D. D. Luther, coll. 1902

5482 $\frac{9711}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.8.

Portage (Naples) beds

Big Sister creek, Angola N. Y.

D. D. Luther, coll. 1902

5483 $\frac{9711}{9}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.9.
Portage (Naples) beds
Big Sister creek, Angola N. Y.
D. D. Luther, coll. 1902

Posidonia venusta Münster *var.* **nitidula** Clarke

5484 $\frac{9712}{1}$ TYPE Posidonia venusta Münster *var.* nitidula Clarke. New York state museum memoir 6. 1903. p.268, pl.12, fig.16.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5485 $\frac{9712}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.17.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5486 $\frac{9712}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.18.
Portage (Naples) beds
Gowanda forks, Cattaraugus co. N. Y.
D. D. Luther, coll. 1897

5487 $\frac{9712}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.12, fig.19.
Portage (Naples) beds Correll's point Lake Erie
J. M. Clarke and D. D. Luther coll. 1898

PRAECARDIUM Barrande

Praecardium duplicatum Münster (sp.)

5488 $\frac{9715}{1}$ HYPOTYPE Cardiola duplicata Münster. Beiträge zur Petrefactenkunde. 1840. Heft 3, p.68.
Praecardium duplicatum Clarke. New York state museum memoir 6. 1903. pl.11, fig 25.
Portage (Naples) beds
Johnson's falls, near Strykersville N. Y.
J. M. Clarke, donor

Praecardium melletes Clarke

5489 $\frac{9716}{1}$ TYPE Praecardium melletes Clarke. New York state museum memoir 6. 1903. p.307, pl.11, fig.20.
Portage (Naples) beds
Forestville, Chautauqua co. N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Praecardium multicostatum Clarke

5490 $\frac{9717}{1}$ TYPE Praecardium multicostatum Clarke. New York state museum memoir 6. 1903. p.308, pl.11, fig.21.
Portage (Naples) beds Forestville N. Y.
D. D. Luther, coll. 1902

5491 $\frac{9717}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.22.
Portage (Naples) beds Forestville N. Y.
D. D. Luther, coll. 1902

5492 $\frac{9717}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig 23.
Portage (Naples) beds Forestville N. Y.
D. D. Luther, coll. 1902

5493 $\frac{9717}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.24.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke, donor

Praecardium vetustum Hall

5494 $\frac{9718}{1}$ HYPOTYPE Cardium? vetustum Hall. Geology of New York; report on the 4th district. 1843. p.245.
Praecardium vetustum Clarke. New York state museum memoir 6. 1903. pl.11, fig.11.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5495 $\frac{9718}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.12.
Portage (Naples) beds Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

5496 $\frac{9718}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.13.
Portage (Naples) beds
Smith's Mills, Chautauqua co. N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5497 $\frac{9718}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.14.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke, donor

5498 $\frac{9718}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.16, 17

Portage (Naples) beds Forestville N. Y.

J. M. Clarke and D. D. Luther, coll. 1898

5499 $\frac{9718}{6}$ HYPOTYPE: HYPOPLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.18.

Portage (Naples) beds Forestville N. Y.

5500 $\frac{9718}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.19.

Portage (Naples) beds Correll's point, Lake Erie

J. M. Clarke and D. D. Luther, coll. 1898

PTERINEA Goldfuss

Pterinea brisa Hall

5501 $\frac{9760}{1}$ HYPOTYPE Pterinea brisa Hall. 20th annual report of the New York state cabinet of natural history. 1867. p.337, pl.14, fig.1.

Hall. 11th annual report of the Indiana state geologist. 1881. pl.27, fig.24.

Niagaran Waldron Ind.

Pterinopecten? atticus *see* Posidonia attica

PTEROCHAENIA Clarke

Pterochaenia cashaquae Clarke

5502 $\frac{9789}{1}$ TYPE: PLASTOTYPE Pterochaenia cashaquae Clarke. New York state museum memoir 6. 1903. p.254, pl.4, fig.20.

Portage (Naples) beds

Cashaqua creek, Livingston co. N. Y.

On slab with types of pl.4, fig.21, 22.

5503 $\frac{9789}{2}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.21, 24.

Portage (Naples) beds

Cashaqua creek, Livingston co. N. Y.

On slab with types of pl 4, fig.20, 22.

5504 $\frac{9789}{3}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.22.

Portage (Naples) beds

Cashaqua creek, Livingston co. N. Y.

On slab with types of pl.4, fig.20, 21.

5505 $\frac{9789}{4}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.23.
Portage (Naples) beds
Bristol hollow, Ontario co. N. Y.

5506 $\frac{9789}{5}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.24.
Portage (Naples) beds
Cashaqua creek, Livingston co. N. Y.

5507 $\frac{9789}{6}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.25.
Portage (Naples) beds
Cashaqua creek, Livingston co. N. Y.

Pterochaenia elmensis Clarke

5508 $\frac{9789a}{1}$ TYPE *Pterochaenia elmensis* Clarke. New York state museum memoir 6. 1903. p.254, pl.4, fig.26.
Portage (Naples) beds
Big Buffalo creek, East Elma Erie co. N. Y.
D. D. Luther, coll. 1897

5509 $\frac{9789a}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.27.
Portage (Naples) beds
Big Buffalo creek, East Elma N. Y.
D. D. Luther, coll. 1897

Pterochaenia fragilis Hall (sp.)

(see *Lunulicardium fragilis* Hall)

5510 $\frac{9401}{10}$ HYPOTYPE: HYPOPLASTOTYPE *Avicula fragilis* Hall. Geology of New York; report on the 4th district. 1843. p.222.
Lunulicardium fragile Hall. Paleontology of New York. 1883. v.5, pt1, plates and explanations.
Pterochaenia fragilis Clarke. New York state museum memoir 6. 1903. pl.5, fig.1.
Portage (Naples) beds Naples, Ontario co. N. Y.
J. M. Clarke, donor

5511 $\frac{9401}{11}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.2.
Genesee shale Bristol, Ontario co. N. Y.
J. M. Clarke, donor

5512 $\frac{9401}{12}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.3.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5513 $\frac{9401}{13}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.4.
Genesee shale Moscow, Livingston co. N. Y.
J. M. Clarke, donor

5514 $\frac{9401}{14}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.5.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5515 $\frac{9401}{15}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.6.
Portage (Naples) shales Naples N. Y.
R. P. Whitfield and C. Van Deloo, coll. 1862

5516 $\frac{9401}{16}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig 7.
Marcellus shale Chapinville, Ontario co. N. Y.
J. M. Clarke, coll. 1888

5517 $\frac{9401}{17}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.8.
Portage (Naples) shale Naples N. Y.
J. M. Clarke, donor

5518 $\frac{9401}{18}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.9, 10.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

Pterochaenia fragilis Hall (sp.) *var.* **orbicularis** Clarke

5519 $\frac{9401a}{1}$ TYPE Pterochaenia fragilis Hall (sp.) var. orbicularis Clarke. New York state museum memoir 6. 1903. p.252, pl.4, fig.17.
Portage (Ithaca) beds
Near Noblesville, Otsego co. N. Y.
D. D. Luther, coll. 1900

5520 $\frac{9401a}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.4, fig.18.
Portage (Ithaca) beds Near Noblesville N. Y.
D. D. Luther, coll. 1900

5521 $\frac{9401a}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.12.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5522 $\frac{9401a}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.13.
Portage (Naples) beds Ithaca, Tompkins co. N. Y.
J. W. Hall and C. Van Deloo, coll. 1866

5523 $\frac{9401a}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.14.
Genesee shale Aurora, Cayuga lake, N. Y.
J. W. Hall and C. Van Deloo, coll. 1867

5524 $\frac{9401a}{6}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.16.
Genesee shale Aurora N. Y.
J. W. Hall and C. Van Deloo, coll. 1867

Pterochaenia perissa Clarke

5525 $\frac{9789b}{1}$ TYPE Pterochaenia perissa Clarke. New York state museum memoir 6. 1903. p.253, pl.4, fig.19.
Portage (Naples) beds Parrish gully, Naples N. Y.
J. M. Clarke, donor

Pterochaenia sinuosa Clarke

5526 $\frac{9789c}{1}$ TYPE Pterochaenia sinuosa Clarke. New York state museum memoir 6. 1903. pl.5, fig.17.
Genesee shale (Genundewa limestone)
Genundewa, Canandaigua lake, N. Y.
J. M. Clarke, donor

5527 $\frac{9789c}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.18, 19.
Genesee shale (Genundewa limestone)
Genundewa N. Y.
J. M. Clarke, donor

5528 $\frac{9789c}{3}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.20, 21.
Genesee shale (Genundewa limestone)
Genundewa N. Y.
J. M. Clarke, donor

5529 9789c/4 TYPE Clarke. New York state museum memoir 6. 1903. pl.5, fig.22.
Genesee shale (Genundewa limestone)
Genundewa N. Y.
J. M. Clarke, donor

Ptychopteria? mesacostalis *see* Posidonia mesacostalis

PUELLA Barrande

Puella sp.?

5530 9815/1 TYPE Puella sp.? Clarke. New York state museum memoir 6. 1903. p.309, pl.11, fig.26.
Portage (Naples) beds
Cook's ravine, Canandaigua lake N. Y.
J. M. Clarke, donor

Puella sp.?

5531 9816/1 TYPE Puella sp.? Clarke. New York state museum memoir 6, 1903. p.309, pl.11, fig.27.
Genesee shale Seneca point, Canandaigua lake N. Y.
J. M. Clarke, donor

5532 9816/2 TYPE Clarke. New York state museum memoir 6. 1903. pl.11, fig.28.
Genesee shale Seneca point, Canandaigua lake, N. Y.
J. M. Clarke, donor

Puella sp.?

5533 9817/1 TYPE Puella sp? Clarke. New York state museum memoir 6. 1903. p.309, pl.11, fig.29.
Genesee shale Iron Bridge Mills, Cayuga co. N. Y.
D. D. Luther, coll. 1897

Ungulina suborbicularis *see* Ontario suborbicularis

Venericardium retrostriatum *see* Buchiola retrostriata

GASTROPODA

BELLEROPHON Montfort

Bellerophon denckmanni Clarke

5534 10018/1 TYPE Bellerophon denckmanni Clarke. New York state museum memoir 6. 1903. p.321, pl.17, fig.24, 26.
Genesee shale (Genundewa limestone)
Middlesex, Yates co. N. Y.
J. M. Clarke, donor

5535 $\frac{10018}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.25.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5536 $\frac{10018}{3}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.27.
Genesee shale (Genundewa limestone)
Bristol, Ontario co. N. Y.
J. M. Clarke, donor

5537 $\frac{10018}{4}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.28.
Genesee shale (Genundewa limestone) Bristol N. Y.
J. M. Clarke, donor

Bellerophon incisum *see* Phragmostoma incisum

Bellerophon koeneni Clarke

5538 $\frac{10019}{1}$ TYPE Bellerophon koeneni Clarke. New York state museum memoir 6. p.320, pl.17, fig.12-14.
Genesee shale (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, donor

5539 $\frac{10019}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.15.
Portage (Naples) beds
Plum creek, Himrod, Yates co. N. Y.
J. M. Clarke, coll. 1895

5540 $\frac{10019}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.16.
Portage (Naples) beds Middlesex, Yates co. N. Y.
J. M. Clarke, donor

5541 $\frac{10019}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.17, 18.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5542 $\frac{10019}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.19.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5543 $\frac{10019}{6}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.20.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5544 $\frac{10019}{7}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.21, 22.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

CALLONEMA Hall

Callonema filosum Clarke

5545 $\frac{10033}{1}$ TYPE: PLASTOTYPE Callonema filosum Clarke. New York state museum memoir 6. 1903. p.337, pl.18, fig.5.
Portage (Naples) beds
Smith's Mills, Chautauqua co. N. Y.
J. M. Clarke, donor

CARINAROPSIS Hall

Carinaropsis ithagenia Clarke

5546 $\frac{10034}{1}$ TYPE Carinaropsis ithagenia Clarke. New York state museum memoir 6. 1903. p.323, pl.16, fig.18, 20.
Portage (Ithaca) beds
Brookins quarry, near Norwich, Chenango co. N. Y.
D. D. Luther, coll. 1900
2 specimens (external and internal casts)

5547 $\frac{10034}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig.19.
Portage (Ithaca) beds
Brookins quarry, near Norwich N. Y.
D. D. Luther, coll. 1900

DIAPHOROSTOMA Fischer

Diaphorostoma (?)

5548 $\frac{10112}{1}$ TYPE Diaphorostoma (?) Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.4, fig.2, 3.
Tully pyrite Canandaigua lake, N. Y.
D. D. Luther, coll.

5549 $\frac{10112}{2}$ TYPE (?) Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.4, fig.7, 8.
Tully pyrite — Canandaigua lake, N. Y.
D D. Luther, coll.

Diaphorostoma lineatum Conrad *mut.* **belial** Clarke (sp.)

5550 $\frac{10113}{1}$ HYPOTYPE Platyostoma belial Clarke. United States geological survey bulletin 16. 1885. p.30.
Diaphorostoma lineatum Conrad mut. belial Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.911, pl.4, fig.9.
Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

Diaphorostoma lutheri Clarke

5551 $\frac{10114}{1}$ TYPE Diaphorostoma lutheri Clarke. New York state museum memoir 6. 1903. p.337, pl.19, fig.10.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor, 1901

5552 $\frac{10114}{2}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.14.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor, 1901

Diaphorostoma pugnus Clarke

5553 $\frac{10115}{1}$ TYPE Diaphorostoma pugnus Clarke. New York state museum memoir 6. 1903. p.338, pl.19, fig.15.
Portage (Naples) beds
Blacksmith ravine, Bristol N. Y.
J. M. Clarke, donor

5554 $\frac{10115}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.16.
Portage (Naples) beds — Fox's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

Diaphorostoma (Naticopsis) rotundatum Clarke

5555 $\frac{10116}{1}$ TYPE: PLASTOTYPE Diaphorostoma (Naticopsis) rotundatum Clarke. New York state museum memoir 6. 1903. p.337, pl.19, fig.11–13.
Portage (Naples) beds — Angola, Erie co. N. Y.
J. M. Clarke, donor

LOXONEMA Phillips

Loxonema danai Clarke

5556 $\frac{10174}{1}$ TYPE: PLASTOTYPE Loxonema danai Clarke. New York state museum memoir 6. 1903. p.333, pl.18, fig.11.
Portage (Naples) beds
Forestville, Chautauqua co. N. Y.
J. M. Clarke, donor

5557 $\frac{10174}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig.12.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5558 $\frac{10174}{3}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig.13.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke, donor

Loxonema delphicola Hall *mut.* moloch Clarke

5559 $\frac{10175}{1}$ HYPOTYPE Loxonema delphicola Hall mut. moloch Clarke. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.913. pl.4, fig.10.
Tully pyrite Moscow, Livingston co. N. Y.
D. D. Luther, coll.

Loxonema multiplicatum Clarke

5560 $\frac{10176}{1}$ TYPE: PLASTOTYPE Loxonema multiplicatum Clarke. New York state museum memoir 6. 1903. p.333, pl.18, fig.14.
Portage (Naples) beds
Upper Portage falls, Genesee river, N. Y.
D. D. Luther, coll. 1897

Loxonema noe Clarke

5561 $\frac{10177}{1}$ TYPE Loxonema noe Clarke. United States geological survey bulletin 16. 1885. p.55.
Clarke. New York state museum memoir 6. 1903. pl.18, fig.6.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5562 $\frac{10177}{2}$ TYPE Clarke New York state museum memoir 6. 1903. pl.18, fig.7.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5563 $\frac{10177}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig.8.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5564 $\frac{10177}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig 9
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5565 $\frac{10177}{5}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig.10.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

MACROCHILINA Bayle

Macrochilina hamiltoniae Hall *mut.* **pygmaea** Loomis

5566 $\frac{10211}{1}$ TYPE Macrochilina hamiltoniae Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.912, pl.4, fig.1.
Tully pyrite — Moscow, Livingston co. N. Y.
D. D. Luther, coll.

Macrochilina hebe Hall *mut.* **pygmaea** Loomis

5567 $\frac{10212}{1}$ TYPE Macrochilina hebe Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.912, pl.4, fig.4.
Tully pyrite — Moscow N. Y.
D. D. Luther, coll.

Macrochilina pygmaea Clarke

5568 $\frac{10213}{1}$ TYPE Macrochilina pygmaea Clarke. New York state museum memoir 6. 1903. p.334, pl.18, fig.17.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5569 $\frac{10213}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig.18.
Genesee shale (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, donor

5570 $\frac{10213}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. p.18, fig.19.
Genesee shale (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, donor

Macrochilina seneca Clarke

5571 $\frac{10214}{1}$ TYPE Macrochilina seneca Clarke. New York state museum memoir 6. 1903. p.334, pl.18, fig.15.
Genesee shale (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, coll. 1899

5572 $\frac{10214}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig.16.
Genesee shale (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, coll. 1899

PALAEOTROCHUS Hall

Palaeotrochus praecursor Clarke

5573 $\frac{10270}{1}$ HYPOTYPE Palaeotrochus praecursor Clarke. United States geological survey bulletin 16. 1886. p.55.
Clarke. New York state museum memoir 6. 1903. pl.19, fig.17.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5574 $\frac{10270}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.18.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5575 $\frac{10270}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.19.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5576 $\frac{10270}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.20.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5577 $\frac{10270}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.21.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5578 $\frac{10270}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl 19, fig.22.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5579 $\frac{10270}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.23.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5580 $\frac{10270}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.24.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5581 $\frac{10270}{9}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.25.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5582 $\frac{10270}{10}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.26.
Portage (Naples) beds
Java Village, Wyoming co. N. Y.
D. D. Luther, coll. 1897

PHRAGMOSTOMA Hall

Phragmostoma chautauquae Clarke

5583 $\frac{10290}{1}$ TYPE: PLASTOTYPE Phragmostoma chautauquae Clarke. New York state museum memoir 6. 1903. p.328, pl.17, fig.1.
Portage (Naples) beds
Smith's Mills, Chautauqua co. N. Y.
J. M. Clarke, donor

5584 $\frac{10290}{2}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.2.
Portage (Naples) beds — Smith's Mills N. Y.
J. M. Clarke, donor

5585 $\frac{10290}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.3.
Portage (Naples) beds
Forestville, Chautauqua co. N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5586 $\frac{10290}{4}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.4.
Portage (Naples) beds — Smith's Mills N. Y.
J. M. Clarke, donor

5587 $\frac{10290}{5}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.5.
Portage (Naples) beds Smith's Mills N. Y.
J. M. Clarke, donor

5588 $\frac{10290}{6}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl 17, fig.6.
Portage (Naples) beds Smith's Mills N. Y.
J. M. Clarke, donor

5589 $\frac{10290}{7}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903 pl.17, fig.7.
Portage (Naples) beds Smith's Mills N. Y.

5590 $\frac{10290}{8}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.8.
Portage (Naples) beds Smith's Mills N. Y.

5591 $\frac{10290}{9}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.9.
Portage (Naples) beds Smith's Mills N. Y.

5592 $\frac{10290}{10}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.10.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5593 $\frac{10290}{11}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.17, fig.11.
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Phragmostoma incisum Clarke

5594 $\frac{10291}{1}$ HYPOTYPE Bellerophon incisum Clarke. United States geological survey bulletin 16. 1885. p.53.
Phragmostoma incisum Clarke. New York state museum memoir 6. 1903. pl.16, fig.7.
Portage (Naples) beds Naples, Ontario co. N. Y.
J. M. Clarke donor

5595 $\frac{10291}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig.8, 14, 15.
Portage (Naples) beds
Whetstone gully, Honeoye lake, N. Y.
J. M. Clarke, donor

5596 $\frac{10291}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig 9, 10.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5597 $\frac{10291}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig.11.
Portage (Naples) beds
Whetstone gully, Honeoye lake, N. Y.
J. M. Clarke, donor

5598 $\frac{10291}{5}$ HYPOTYPE: HYPOPLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig.12.
Portage (Naples) beds
Whetstone gully, Honeoye lake, N. Y.
J. M. Clarke, donor

5599 $\frac{10291}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig.13.
Portage (Naples) beds
Whetstone gully, Honeoye lake, N. Y.
J. M. Clarke, donor

5600 $\frac{10291}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig 16.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

5601 $\frac{10291}{8}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig.17.
Portage (Naples) beds — Naples N. Y.
J. M. Clarke, donor

Phragmostoma natator Hall

5602 $\frac{10292}{1}$ HYPOTYPE Phragmostoma natator Hall. 15th annual report of the New York state cabinet of natural history. 1862. p.60.
Clarke. New York state museum memoir 6. 1903. pl.16, fig.1.
Portage (Naples) beds — Naples valley, N. Y.
J. M. Clarke, donor

5603 $\frac{10292}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903 pl 16, fig.2.
Portage (Naples) beds — Naples valley, N. Y.
J. M. Clarke, donor

5604 $\frac{10292}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig.3.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5605 $\frac{10292}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig.4.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5606 $\frac{10292}{5}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.16, fig.5.
Portage (Naples) beds Naples N Y.
J. M. Clarke, donor

Phragmostoma cf. triliratum Hall

5607 $\frac{10016}{3}$ HYPOTYPE Phragmostoma cf. triliratum Clarke. New York state museum memoir 6. 1903. pl.16, fig.6.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

Platyostoma belial *see* Diaphorostoma lineatum *mut.* belial

PLEUROTOMARIA Defrance

Pleurotomaria capillaria *mut.* cognata *mut. nov.* Clarke

5608 $\frac{10403}{1}$ TYPE Pleurotomaria capillaria mut. cognata mut. nov. Clarke. New York state museum memoir 6. 1903. p.317, pl.19, fig 27.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5609 $\frac{10403}{2}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.28.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5610 $\frac{10403}{3}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.29.
Portage (Naples) beds Naples N. Y.
J. M. Clarke, donor

5611 $\frac{10403}{4}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl 19, fig.30.
Portage (Naples) beds Lodi falls, Seneca co. N. Y.
J. M. Clarke, donor

Pleurotomaria capillaria Conrad *mut.* **pygmaea** Loomis

5612 $\frac{10404}{1}$ TYPE Pleurotomaria capillaria Conrad mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.912, pl.4, fig 6.
Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

Pleurotomaria ciliata Clarke

5613 $\frac{10405}{1}$ TYPE Pleurotomaria ciliata Clarke. New York state museum memoir 6. 1903. p.318, pl.20, fig.8, 11.
Portage (Naples) beds
Whetstone gully, Conesus lake, N. Y.
J. M. Clarke, donor

5614 $\frac{10405}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.9.
Portage (Naples) beds
Whetstone gully, Conesus lake, N. Y.
J. M. Clarke, donor

5615 $\frac{10405}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.10.
Portage (Naples) beds
Whetstone gully, Conesus lake, N. Y.
J. M. Clarke, donor

5616 $\frac{10405}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.12, 13.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5617 $\frac{10405}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.14.
Portage (Naples) beds
Whetstone gully, Conesus lake, N. Y.
J. M. Clarke, donor

Pleurotomaria genundewa Clarke

5618 $\frac{10406}{1}$ TYPE: PLASTOTYPE Pleurotomaria genundewa Clarke. New York state museum memoir 6. 1903. p.319, pl.19, fig.33.
Genesee shale (Genundewa limestone)
Middlesex, Yates co. N. Y.
J. M. Clarke, donor

5619 $\frac{10406}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.34.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5620 $\frac{10406}{3}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.1, 5.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5621 $\frac{10406}{4}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.2.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5622 $\frac{10406}{5}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.3.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5623 $\frac{10406}{6}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.4.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5624 $\frac{10406}{7}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl 20, fig.6.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

5625 $\frac{10406}{8}$ TYPE: PLASTOTYPE Clarke. New York state museum memoir 6. 1903. pl 20, fig.7.
Genesee shale (Genundewa limestone)
Middlesex N. Y.
J. M. Clarke, donor

Pleurotomaria itylus Clarke

5626 $\frac{10407}{1}$ TYPE Pleurotomaria itylus Clarke. New York state museum memoir 6. 1903. pl.19, fig.31, 32.
Portage (Naples) beds
Forestville, Chautauqua co. N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Pleurotomaria itys Hall *mut.* pygmaea Loomis

5627 $\frac{10408}{1}$ TYPE Pleurotomaria itys Hall mut. pygmaea Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.913, pl.4, fig.5.

Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

PROTOCALYPTRAEA Clarke

Protocalyptraea marshalli Clarke

5628 $\frac{10430}{1}$ TYPE Protocalyptraea marshalli Clarke. American geologist. 1894. 13:334; p.332, fig 10, 11, p.333, fig.12.

Clarke. New York state museum memoir 6. 1903. pl.19, fig.1–3.

Portage (Naples) beds
Whetstone gully, near Honeoye lake, N. Y.
J. M. Clarke, donor

5629 $\frac{10430}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903 pl.19, fig.4.

Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5630 $\frac{10430}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.19, fig.5, 6.

Portage (Naples) beds — Naples, Ontario co. N. Y.
J. M. Clarke, donor

Protocalyptraea styliophila Clarke

5631 $\frac{10431}{1}$ TYPE Protocalyptraea styliophila Clarke. American geologist. 1894. 13:334; p.333, fig.13.

Clarke. New York state museum memoir 6. 1903. pl.19, fig.7–9.

Genesee shale (Genundewa limestone)
Canandaigua lake, N. Y.
J. M. Clarke, donor

PROTOSPIRIALIS Clarke

Protospirialis minutissima Clarke

5632 $\frac{10435}{1}$ TYPE Platyostoma? minutissima Clarke. United States geological survey bulletin 16. 1885. p.55.

Protospirialis minutissima Clarke. New York state museum memoir 6. 1903. pl.20, fig.15.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5633 $\frac{10435}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.16.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5634 $\frac{10435}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.17.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5635 $\frac{10435}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.18.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5636 $\frac{10435}{5}$ TYPE Clarke. New York state museum memoir 6. 1903. pl 20, fig.19.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

TROPIDOCYCLUS Clarke

Tropidocyclus hyalinus Clarke

5637 $\frac{10590}{1}$ TYPE Tropidocyclus hyalinus Clarke. New York state museum memoir 6. 1903. p.331, pl.18, fig.1.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5638 $\frac{10590}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig.2.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5639 $\frac{10590}{3}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig.3.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

5640 $\frac{10590}{4}$ TYPE Clarke. New York state museum memoir 6. 1903. pl.18, fig.4.
Portage (Naples) beds Honeoye lake, N. Y.
J. M. Clarke, donor

PTEROPODA

HYOLITHELLUS Billings

Hyolithellus micans Billings

5641 $\frac{11015}{1}$ HYPOTYPE Hyolithellus micans Billings. Canadian naturalist, 2d ser. 1871: 4:215.

Ruedemann. New York state museum bulletin 49. 1901. pl.2, fig.11.

Trenton conglomerate

Rysedorph hill, Rensselaer co N. Y.

Hyolithes neapolis *see* Hyolithus neapolis

HYOLITHUS Eichwald

Hyolithus neapolis Clarke

5642 $\frac{11029}{1}$ PLASTOTYPE Clarke. United States geological survey bulletin 16. 1885. pl 3, fig 4,5.

Clarke. New York state museum memoir 6. 1903. pl.20, fig 23.

Portage (Naples) beds Naples N. Y.

J. M. Clarke, donor

5643 $\frac{11029}{2}$ HYPOTYPE Hyolithes neapolis Clarke. United States geological survey bulletin 16. 1885. p.56.

Hyolithus neapolis Clarke. New York state museum memoir 6. 1903. pl.20, fig.22.

Portage (Naples) beds Naples N. Y.

J. M. Clarke, donor

5644 $\frac{11029}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig 24.

Portage (Naples) beds Naples N. Y.

J. M. Clarke, donor

5645 $\frac{11029}{4}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig 25.

Portage (Naples) beds Naples N. Y.

J. M. Clarke, donor

5646 $\frac{11029}{5}$ HYPOTYPE Clarke. New York state musem memoir 6. 1903. pl.20, fig. 26.

Portage (Naples) beds Naples N. Y.

J. M. Clarke, donor

5647 $\frac{11029}{6}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl 20, fig 27–29.
Portage (Naples) beds — Honeoye lake, N. Y.
J. M. Clarke, donor

5648 $\frac{11029}{7}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. pl.20, fig.30.
Portage (Naples) beds — Naples N. Y.
D. D. Luther, coll. 1902

CEPHALOPODA

BACTRITES Sandberger

Bactrites (sp. ?) *mut.* parvus Loomis

5649 $\frac{12043}{1}$ TYPE Bactrites (sp.?) mut. parvus Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p 916, pl 5, fig.4, 5.
Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

Bactrites? sp. *mut.* pygmaeus Loomis

5650 $\frac{12044}{1}$ TYPE Bactrites? sp. mut. pygmaeus Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.915, pl.4, fig 12, 13.
Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

CHILOCERAS Salter

Chiloceras sp. Clarke

5651 $\frac{12095}{1}$ TYPE Chiloceras sp. Clarke. New York state museum memoir 6. 1903. p.344, fig.14.
Portage (Naples) beds
Union Corners, Livingston co. N. Y.
J. M. Clarke, coll.

GEPHYROCERAS Hyatt

Gephyroceras cf. domanicense Holzapfel

5652 $\frac{12164}{1}$ HYPOTYPE Gephyroceras domanicense Holzapfel. Mémoires du comité géologique. 1899. v.12, no.3, p.32.
Gephyroceras cf. domanicense Clarke. New York state museum memoir 6. 1903. p 345, fig.15(a).
Portage (Naples) beds
Forestville, Chautauqua co. N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

5653 $\frac{12164}{2}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. p.345, fig.15(b).
Portage (Naples) beds Forestville N. Y.
D. D. Luther, coll. 1902

5654 $\frac{12164}{3}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. p.345, fig.15(c).
Portage (Naples) beds Forestville N. Y.
J. M. Clarke and D. D. Luther, coll. 1898

Goniatites astarte *see* Tornoceras uniangulare *mut.* astarte

ORTHOCERAS Breynius

Orthoceras asmodeus *see* Tentaculites gracilistriatus *mut.* asmodeus

Orthoceras mephisto *see* Orthoceras scintilla *mut.* mephisto

Orthoceras nuntium Hall

5655 $\frac{12388}{6}$ HYPOTYPE Orthoceras nuntium Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl 5, fig.9.
Tully pyrite Canandaigua lake, N. Y.
D. D. Luther, coll.

Orthoceras scintilla Hall (?) *mut.* **mephisto** Clarke

5656 $\frac{12425}{1}$ HYPOTYPE Orthoceras mephitos Clarke. United States geological survey bulletin 16. 1885. p 29.
Orthoceras scintilla Hall (?) mut. mephisto Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.4, fig.14.
Tully pyrite Canandaigua lake, N. Y.
D. D. Luther, coll.

Orthoceras subulatum Conrad *mut.* **pygmaeum** Loomis

5657 $\frac{12426}{1}$ TYPE Orthoceras subulatum Conrad mut. pygmaeum Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.914, pl.5, fig.6.
Tully pyrite Canandaigua lake, N. Y.
D. D. Luther, coll.

5658 $\frac{12426}{2}$ TYPE Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.5, fig.7.

Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

Orthoceras stebos *see* Tentaculites bellulus *mut.* stebos

TORNOCERAS Hyatt

Tornoceras bicostatum Hall (sp.)

5659 $\frac{12540}{10}$ HYPOTYPE Clarke. New York state museum memoir 6. 1903. p 346, fig.16.

Portage (Naples) beds
Correll's point, Lake Erie
J. M. Clarke and D. D. Luther, coll. 1898

Tornoceras uniangulare Conrad (sp.)

5660 $\frac{12544}{6}$ HYPOTYPE Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.5, fig.3.

Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

Tornoceras uniangulare Conrad *mut.* **astarte** Clarke

5661 $\frac{12547}{1}$ HYPOTYPE Goniatites astarte Clarke. United States geological survey bulletin 16. 1885. p.29.

Tornoceras uniangulare Conrad mut. astarte Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl 5, fig.1.

Tully pyrite — Canandaigua lake, N. Y.
D. D. Luther, coll.

5662 $\frac{12547}{2}$ HYPOTYPE Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.5, fig.2.

Tully pyrite
Livonia salt shaft, Livingston co. N. Y.
D. D. Luther, coll.

CRUSTACEA

Acidaspis fimbriata *see* Ceratocephala (Acidaspis) fimbriata

BEYRICHIA McCoy

Beyrichia dagon Clarke

5663 $\frac{13087}{1}$ HYPOTYPE Beyrichia dagon Clarke. United States geological survey bulletin 16. 1885. p.29.

Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.5, fig.12–14.

Tully pyrite Greigsville, Livingston co. N. Y.

D. D. Luther, coll.

CERATOCEPHALA Warder

Ceratocephala (Acidaspis) fimbriata Hall (sp.)

5664 $\frac{13225}{1}$ TYPE Acidaspis fimbriata Hall. Transactions of the Albany institute. 1881. 10:20 (abstract).

Acidaspis fimbriata Hall. 11th annual report of the Indiana state geologist. 1881. pl.33, fig.11.

Niagaran Waldron Ind.

C. D. Walcott and C. Van Deloo, coll. 1878

Cryphaeus boothi var. calliteles *see* Dalmanites (Cryphaeus) boothi *var.* calliteles

Cypridina serratostriata *see* Entomis serratostriata

DALMANITES (Emmrich) Barrande

Dalmanites (Cryphaeus) boothi Green (sp.)
var. **calliteles** Green

5665 $\frac{13369}{18}$ HYPOTYPE Cryphaeus boothi var. calliteles Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.5, fig.15.

Tully pyrite Moscow, Livingston co. N. Y.

D. D. Luther, coll.

DOLICHOPTERUS Hall

Dolichopterus ??

5666 $\frac{13430}{1}$ HYPOTYPE Dolichopterus ?? Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1262, pl.12, fig.5.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

ENTOMIS Jones

Entomis prosephina Loomis

5667 $\frac{13510}{1}$ TYPE Entomis prosephina Loomis. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.918, pl.5. fig.10, 11.
Tully pyrite Canandaigua lake, N. Y.
D. D. Luther, coll.

Entomis serratostriata Sandberger (sp.)

5668 $\frac{13511}{1}$ HYPOTYPE Cypridina serratostriata Sandberger. Leonhardt & Bronn's Jahrb. 1842. p.226.
Entomis serratostriata Clarke. New York state museum memoir 6. 1903. p.344, fig.12.
Portage (Naples) beds
Union Springs, Livingston co. N. Y.
J. M. Clarke, coll. 1890

Entomis variostriata Clarke

5669 $\frac{13512}{1}$ HYPOTYPE Entomis variostriata Clarke. Neues Jahrb. für Mineral. 1884. p.184.
Clarke. New York state museum memoir 6. 1903. p.344, fig.13.
Portage (Naples) beds Union Springs N. Y.
J. M. Clarke, coll. 1890

EURYPTERUS De Kay

Eurypterus pittsfordensis Sarle

5670 $\frac{13566}{1}$ TYPE Eurypterus pittsfordensis Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1098, pl.10, fig 7.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5671 $\frac{13566}{2}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.15, fig 1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase
On slab with types of pl.15, fig. 3; pl.18, fig. 1.

5672 $\frac{13566}{3}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.15, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5673 $\frac{13566}{4}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.15, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

On slab with types of pl.15, fig.1; pl.18, fig. 1.

5674 $\frac{13566}{5}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.16.
Salina (Pittsford shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5675 $\frac{13566}{6}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.17, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5676 $\frac{13566}{7}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.17, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5677 $\frac{13566}{8}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.18.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

On slab with types of pl.15, fig.1; pl.15, fig.3.

5678 $\frac{13566}{9}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.19.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5679 $\frac{13566}{10}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.20, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5680 $\frac{13566}{11}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.20, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N Y.
C. J. Sarle purchase

5681 $\frac{13566}{12}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.20, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5682 $\frac{13566}{13}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.20, fig 4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5683 $\frac{13566}{14}$ TYPE Sarle New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.20, fig.5.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5684 $\frac{13566}{15}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.20, fig.6.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5685 $\frac{13566}{16}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.22, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J Sarle purchase

5686 $\frac{13566}{17}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.23, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5687 $\frac{13566}{18}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.23, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5688 $\frac{13566}{19}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.23, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5689 $\frac{13566}{20}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.23, fig.4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5690 $\frac{13566}{21}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.24, fig 2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5691 $\frac{13566}{22}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.24, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5692 $\frac{13566}{23}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.24, fig. 4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5693 $\frac{13566}{24}$ TY Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.24, fig.5.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford, N. Y.
C. J. Sarle purchase

5694 $\frac{13566}{25}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.25, fig.4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5695 $\frac{13566}{26}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.25, fig.5.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5696 $\frac{13566}{27}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.25, fig.6.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

EURYPTERID ?

5697 $\frac{13575}{1}$ TYPE (unknown eurypterid) Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1105, pl.26, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5698 $\frac{13575}{2}$ TYPE (original & counterpart) Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.26, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5699 $\frac{13575}{3}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.26, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

HUGHMILLERIA Sarle

Hughmilleria socialis Sarle

5700 $\frac{13590}{1}$ TYPE Hughmilleria socialis Sarle. New York state bulletin 69; annual report of the state paleontologist. 1903. p.1091, pl.6, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase
On slab with types of pl.7, 8.

5701 $\frac{13590}{2}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.7, fig 1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase
On slab with types of pl.6, 8.

5702 $\frac{13590}{3}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.8, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase
On slab with types of pl.6, 7.

5703 $\frac{13590}{4}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.9, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5704 $\frac{13590}{5}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.10, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5705 $\frac{13590}{6}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.10, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5706 $\frac{13590}{7}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.10, fig.3,
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5707 $\frac{13590}{8}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.10, fig.4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5708 $\frac{13590}{9}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.10, fig.5.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5709 $\frac{13590}{10}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.10, fig.6.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5710 $\frac{13590}{11}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.10, fig.8 (2 specimens).
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5711 $\frac{13590}{12}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.10, fig.9.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5712 $\frac{13590}{13}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.11, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5713 $\frac{13590}{14}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.11, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5714 $\frac{13590}{15}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.11, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5715 $\frac{13590}{16}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.11, fig.4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5716 $\frac{13590}{17}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.11, fig.5.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5717 $\frac{13590}{18}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.11, fig.6.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5718 $\frac{13590}{19}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.11, fig.7.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5719 $\frac{13590}{20}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.12, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5720 $\frac{13590}{21}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.12, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5721 $\frac{13590}{22}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.12, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5722 $\frac{13590}{23}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.12, fig.4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5723 $\frac{13590}{24}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.12, fig.6.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5724 $\frac{13590}{25}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.12, fig.7.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5725 $\frac{13590}{26}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.12, fig.8.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5726 $\frac{13590}{27}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.13, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5727 $\frac{13590}{28}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.13, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C J. Sarle purchase

5728 $\frac{13590}{29}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.13, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.

5729 $\frac{13590}{30}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.13, fig.4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5730 $\frac{13590}{31}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.14, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5731 $\frac{13590}{32}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.14, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5732 $\frac{13590}{33}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.14, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5733 $\frac{13590}{34}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.14, fig 4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5734 $\frac{13590}{35}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.14, fig.5.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5735 $\frac{13590}{36}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.14, fig.6.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5736 $\frac{13590}{37}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.14, fig.7.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5737 $\frac{13590}{38}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.14, fig.8.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5738 $\frac{13590}{39}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.14, fig.9.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5739 $\frac{13590}{40}$ TYPE Sarle. New York state museum bulletin 69; annual
report of the state paleontologist. 1903. pl.14, fig.10.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5740 $\frac{13590}{41}$ TYPE Sarle. New York state museum bulletin 69; annual
report of the state paleontologist. 1903. pl.15, fig.4.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5741 $\frac{13590}{42}$ TYPE Sarle. New York state museum bulletin 69; annual
report of the state paleontologist. 1903. pl.15, fig 5.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5742 $\frac{13590}{43}$ TYPE Sarle. New York state museum bulletin 69; annual
report of the state paleontologist. 1903. pl.15, fig.6.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C J. Sarle purchase

5743 $\frac{13590}{44}$ TYPE Sarle. New York state museum bulletin 69; annual
report of the state paleontologist. 1903. pl.24, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5744 $\frac{13590}{45}$ TYPE Sarle. New York state museum bulletin 69; annual
report of the state paleontologist. 1903. pl.25, fig.1.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5745 $\frac{13590}{46}$ TYPE Sarle. New York state museum bulletin 69; annual
report of the state paleontologist. 1903. pl.25, fig.2.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C. J. Sarle purchase

5746 $\frac{13590}{47}$ TYPE Sarle. New York state museum bulletin 69; annual
report of the state paleontologist. 1903. pl.25, fig.3.
Salina (Pittsford) shale
Erie canal, 2 miles northwest of Pittsford N. Y.
C J. Sarle purchase

5747 $\frac{13590}{48}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.26, fig.4.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

5748 $\frac{13590}{49}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.26, fig.5.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

Hughmilleria socialis Sarle *var.* robusta Sarle

5749 $\frac{13591}{1}$ TYPE Hughmilleria socialis Sarle var. robusta Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1007, pl.21, fig.1.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

5750 $\frac{13591}{2}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.21, fig.2.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

5751 $\frac{13591}{3}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.21, fig.3.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

PTERYGOTUS Agassiz

Pterygotus sp.

5752 $\frac{14081}{1}$ TYPE Pterygotus sp. Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1104, pl.24, fig.6.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

Pterygotus sp.

5753 $\frac{14082}{1}$ TYPE Pterygotus sp. Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p 1104, pl.24, fig.8.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

Pterygotus monroensis Sarle

5754 $\frac{14083}{1}$ TYPE Pterygotus monroensis Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. p.1102, pl.24, fig.7.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

5755 $\frac{14083}{2}$ TYPE Sarle. New York state museum bulletin 69; annual report of the state paleontologist. 1903. pl.24, fig.9.

Salina (Pittsford) shale

Erie canal, 2 miles northwest of Pittsford N. Y.

C. J. Sarle purchase

RIBEIRIA Sharpe

Ribeiria? prosseri Clarke

5756 $\frac{14135}{1}$ TYPE Ribeiria? prosseri Clarke. New York state museum memoir 6. 1903. Explanation of pl.9; pl.9, fig.1.

Portage (Oneonta) sandstone

Near Livingstonville, Schoharie co. N. Y.

C. S. Prosser, coll.

5757 $\frac{14135}{2}$ TYPE Clarke. New York state museum memoir 6. 1903. Explanation of pl.9; pl.9, fig.2.

Portage (Oneonta) sandstone

Near Livingstonville N. Y.

C. S. Prosser, coll.

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Pterochaenia elmensis, 5508, 09
Pterochaenia fragilis, 5510, 12, 14, 15, 17, 18
Pterochaenia fragilis *var.* orbicularis, 5521, 22
Pterochaenia perissa, 5525
Puella *sp.* ?, 5530

Gastropoda

Bellerophon koeneni, 5539, 40
Callonema filosum, 5545
Diaphorostoma lutheri, 5551, 52
Diaphorostoma pugnus, 5553, 54
Diaphorostoma (Naticopsis) rotundatum, 5555
Loxonema danai, 5556-58
Loxonema multiplicatum, 5560
Loxonema noe, 5561-65
Macrochilina pygmaea, 5568
Palaeotrochus praecursor, 5573-82
Phragmostoma chautauquae, 5583-93
Phragmostoma incisum, 5594-5601
Phragmostoma natator, 5602-06
Phragmostoma *cf.* triliratum, 5607
Pleurotomaria capillaria *mut.* cognata *mut. nov.*, 5608-11

Pleurotomaria ciliata, 5613-17
Pleurotomaria itylus, 5626
Protocalyptraea marshalli, 5628-30
Protospirialis minutissima, 5632-36
Tropidocyclus hyalinus, 5637-40

Pteropoda

Hyolithus neapolis, 5642-48

Cephalopoda

Chiloceras *sp.*, 5651
Gephyroceras *cf.* domanicense, 5652-54
Tornoceras bicostatum, 5659

Crustacea

Entomis serratostriata, 5668
Entomis variostriata, 5669

ITHACA BEDS

Lamellibranchiata

Pterochaenia fragilis *var.* orbicularis, 5519, 20

Gastropoda

Carinaropsis ithagenia, 5546, 47

ONEONTA BEDS

Crustacea

Ribeiria ? prosseri, 5756, 57

CHEMUNG BEDS

Spongiae

Hyphantaenia chemungensis, 5161

Lamellibranchiata

Lunulicardium (Pinnopsis) acutirostrum, 5335

PERCÉ

A brief sketch of its geology

BY JOHN M. CLARKE

In seeking the solution of some problems pertaining to the distribution of the ancient faunas of New York, and the nature and extent of the old land barriers and sea channels, one follows only a blind lead if respect is had alone to such evidence as is found within our own political boundaries. In the conservation of the factors necessary to the reconstitution of these early stages in our history, nature has been kind to New York and in the quality of fulness her ancient faunas are not often excelled, but within these confines is but a part of the story; now and again a stage has been skipped here which is recorded elsewhere, or a phase is but obscurely presented in the panorama of New York events which in neighboring territories is portrayed with lucid cogency.

Much of interest lies in the time and mode of introduction into New York of the earliest faunas of the Devonic age. Here they are represented in various degrees of effectiveness and profusion, and for the most part follow with little evidence of interruption on those of the great Siluric age preceding. The pathway of movement of these faunas along the old continental border lies to the northeast and to the southwest, and the labors of our predecessors and colleagues in the latter region have thrown much light on their distribution and travels through what is now the region of the Appalachian mountains but what was then off the coast or along the water ways of the ancient continent termed *Appalachia.*

Seeking such clues to the northeast led us a few years ago into the county of Gaspé, province of Quebec, and the region just north of Gaspé bay, and likewise to the exposures about Dalhousie N. B. at the head of the Bay of Chaleurs, places where unequaled opportunity is afforded for the study of some of the New York faunas

PERCÉ ROCK

under a new aspect and in profuse development. More recently, on a similar errand, the writer has exploited the same factors as developed about the village of Percé on the coast of Gaspé just south of Malbay and about 20 miles due south of the north shore of Gaspé bay. In due time the results of the studies thus made will be presented in some detail for the comparison of these ancient faunas with those of New York, for quite extensive collections have been brought together from all the points mentioned, and we may look for an important elucidation therefrom of some of the problems to which reference has been made.

In this paper, however, it is not so much the purpose to enter on comparisons of results and correlations of faunas as to expound with some brevity the singularly interesting geologic structure prevailing at and about Percé, as derived from observations made in the course of assembling the fossil faunas of the region.

The ancient fishing village of Percé is a spot of extraordinary beauty of situation. It lies exposed to the full force of the sea on the easternmost part of the Gaspé peninsula and no place could display with more potency the tremendous destructive power of the sea than this broken and deeply gnawed coast against which the northeast blasts have beaten ages long. It is an old settlement, one of the oldest in America. Soon after Jacques Cartier in 1535 roasted in the Bay of Chaleurs and planted a cross at Douglastown on Gaspé bay, fisherpeople from the shores of Brittany and the Channel islands settled here under the overshadowing protection of the stupendous and glorious Rocher Percé, from which the place takes name and which today draws the amazed wonder of every passing sea traveler. The narrow beach to the north of the rock and the long beach below afforded a base of operations for the fishing, and here a settlement was made long before Hendrik Hudson had wet keel in the waters of New York.

Isolated and towering stands the Percé rock at the angle between the North and South beaches, cut off from the shore by an interval of 300 feet, over which the waters roll, except at ebb tide, and beneath which lies the zone of a great displacement of the rock masses. All other presentments of the gnawing power of the ocean which the

writer has studied on American shores, in northern Scotland at Scrabster and Caithness, in Hoy and the other islands of the Orkneys, are surpassed in magnitude and effect by this leviathan rock. It lies like an immense Atlantic liner, almost at right angles to the course of the South cove, headed inward to the North cove wharf. Its limestone strata, which stand vertical, rise to a hight of 290 feet at its highest landward apex, where today a weathered joint face hangs out a triangular rock mass like a pennant flying at foremast peak.

From the sharp landward bow the massive widens outward to a diameter of about 300 feet and extends in length seaward 1500 feet,

Seaward face of the pillar at outer end of Percé rock; showing the arch

its top sloping with undulating surface rapidly at first and then more gently backward. Sternward stands an isolated rock pillar, remnant of a fallen arch which the seas brought down, as my good friend Philip Le Boutillier tells me, on a rough 17th of June 1845. But the rock is still tunneled aft by a fine arch through which a boat at sail might pass were it not for the breakers. On its rearward sea face is another and smaller arch. The summit of the rock is the breeding-ground of thousands of gulls and cormorants, which make an ever moving halo of white and black about the grassy slopes and jagged asperities of the surface and whose screams and calls are as sempiternal as the breaking of the surf on the fallen rocks. The cliff is virtually inaccessible. Local traditions and Sir Gilbert Parker tell of its having been scaled, but be this as it may, the walls

Percé and rock from the south. At the left Mt Joli, Cap Canon and the South cove

are sheer and would demand surrender of the most daring. Clothed in tints of red and yellow, which are the natural shades of the rock, and veined with streaks of white, the colors of the cliffs change with every passing cloud, alive with bright purples and lustrous bronze as the sun shines full on it, in the cloud filtered light hanging like an oriental tapestry in soft madders and browns, and when the land mist hangs over it or the nor'easter is buffeting it, dark and minatory, all its soft lines lost and its asperities stiffened in resistance.

Turning landward the eye rests first on the topography of the shore line, Mt Joli, a low truncated rock cone connected at low tide with the Pierced rock by a sand bar, and about a hundred yards away, hence extending southward into another small headland, Cap Canon, sometimes Battery point, all a rock escarpment of vertical strata not more than 100 feet high at any point. To the south of this opens the broad Robin fishing beach, which reaches away to the nearly horizontal outcrops of red conglomerate at the opening of Lenfesty's brook and beyond to the headland which bounds the South cove, 2 miles away, Cap Blanc or Whitehead; another vertical mass of limestones lying between and beneath the red rocks. To the north of Mt Joli and the beach of the North cove, begin the Murailles, the high rocky sea wall which fronts the Malbay, rising with a deeply notched sky line in grassy and deeply furrowed slopes and falling off sheer to the water's edge; the tattered remains of a mountain which stretched away into Malbay but has yielded its better part to the restless tooth of the sea. The effect on the landscape of this ragged escarpment is very striking but its impressiveness is appreciated best only from the sea, from which it is alone approachable. At the north end of the North cove the escarpment rises abruptly in the calcareous and arenaceous shales of Cap Barré; thence northward framing the angular recesses beaten out by the sea, the cliff becomes even higher till the line reaches Red peak at the north and falls off abruptly into the gorge of the Grande Coupe. Except for Cap Barré these rocks are brilliantly tinted with reds and yellows and, we shall presently observe, were a part of the tinted strata comprising the Percé rock, though here the angle of their slope is greatly altered and nearly conforms to the slopes of the mountain surface.

All these bold contours are brought closely together so that in the radius of a mile from the courthouse we embrace the Murailles, cliffs of Joli, Canon, the Percé rock, the broad intervales of the coves and the low south escarpments of the horizontal conglomerate. And behind them all, as a background to the picture, rises Mt Ste Anne, its lofty perpendicular precipices on the eastern face rising to a hight of about 1400 feet. On the slopes of this easternmost member of the cluster of summits known as Percé mountain, pious ardor has cleared a broad way to the shrine at the top whence the eye travels without obstruction to Anse du Cap and Grande Rivière southward, and northward to Pointe St Peter across Malbay and to Shiphead and the shores of Grande Grève across Gaspé bay; inland over the rolling timbered wilderness toward the Shickshock mountains, and seaward beyond the Percé rock to the island of Bonaventure 3 miles away. This mountain is the summit of the great cap of red conglomerate which lies over and against the erect limestones of Percé, Cap Canon and Cap Blanc, extends downward to the sea at the Robin beach and makes the Percé reef, and doubtless continues beneath the water to Bonaventure island where only this rock is found.

From the slopes of Mt Ste Anne flow the little drainage ways of the region, the stream of Le Coulé or Barré brook to the North beach, Robin brook to the South beach and Lenfesty's brook directly through the rising escarpment of the Bonaventure rocks to the south.

This brief sketch of the topography of Percé will serve as the only necessary introduction to the sketch of its geology which, without going far afield from the confines of the settlement, follows.

GEOLOGY

Pretty much all that has been known of the geology of this region we still owe to Sir William Logan, first director of the Geological Survey of Canada. In 1844, the second season of his field work in this capacity, Sir William made it his business to reconnoiter the rocky and wild coasts of the Gaspé country, then and in the season of 1845 making traverses from the Gulf of St Lawrence to the Bay

SECTION ALONG THE COAST FROM ROBIN BEACH TO PERCÉ ROCK

of Chaleurs, "living" as he has said "the life of a savage, sleeping on the beach in a blanket sack with my feet to the fire, seldom taking my clothes off, eating salt pork and ship's biscuit, occasionally tormented with mosquitos." The venerable Mr Philip Le Boutillier tells me of having piloted Sir William about the rocks of Percé and with him scaling the summit of Mt Ste Anne.

In his classical *Geology of Canada* published in 1863 Logan summarized the results of his observations here, and that part of his work in which our interest more specially lies is his detailed account of the limestones, sandstones and conglomerates of the region, enormous series of sediments which he termed the Gaspé limestones, Gaspé sandstones and Bonaventure conglomerates. Several of the Canadian geologists have added much to our knowledge of these formations; Dr Robert Bell, who early explored the region; Sir William Dawson, who studied the plant remains of the Gaspé sandstone; Elkanah Billings, who has made known almost our entire equipment of facts concerning the animal fossils of the rocks; R. W. Ells, who as late as 1882 reviewed the general geologic features of the country and added some important details, while Dr H. M. Ami has contributed a few observations on the faunas.

The Gaspé limestones were defined by Logan from their most remarkable development on the narrow tongue of land which constitutes the peninsula of Cape Gaspé eastward of Cape Rozier on the north and Little Gaspé on the south. Here the succession is apparently uninterrupted, the dip estimated at about s.w. 24°, and the series rests unconformably on the shales of Cambric age at Cape Rozier. Through this narrow neck of land not more than a mile across from the Gulf of St Lawrence to Gaspé bay at Grande Grève run two limestone escarpments, the northern terminating in Cape Gaspé, the southern in Shiphead and the two separated by an eroded, not structural, drainage way. Logan estimated the thickness of this continuous mass at about 2000 feet, and divided it into eight parts, divisions 1 to 8, between which was found no evidence of unconformity but some notable distinctions in quality, the strata becoming more highly calcareous with some intermixture of arenaceous matter toward the top. All were re-

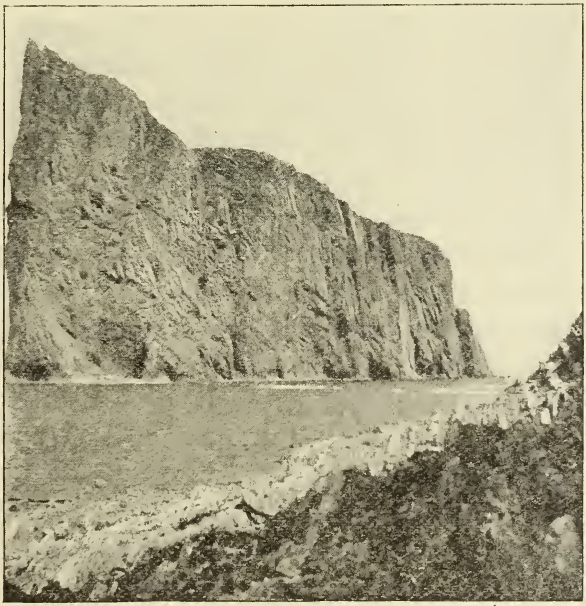
garded by him as of the age of the Lower Helderberg of New York, at a time when the Helderberg fauna was not estimated with precision. Almost all the divisions were found to be fossiliferous, but the uppermost, 7 and 8, specially so.

It became evident from the identification of the fossils of the upper beds by Billings that divisions 7 and 8 correspond more nearly in fauna to the Oriskany of New York than to the Helderberg, and these have been generally conceded to have this equivalence, but of the fauna of the lower beds, its composition and variations, we know only enough to see therein clues to the origin of the later fauna and invaluable lights on the derivation of all early Devonic faunas of the Atlantic and Mississippian provinces. Contrasted with the other beds in profusion of fossils and diversity of species, divisions 7 and 8 have been distinctively designated, Dr Ami having proposed to call these beds the Grande Grève limestones. To them Logan ascribed a thickness of about 800 feet, and in them is a fauna which differs from that of the Oriskany of eastern New York in as many respects as it agrees therewith and yet is bound to it by such striking paleontologic features as the coexistence of Rensselaeria, Megalanteris, Hipparionyx, Chonostrophia, Spirifer murchisoni, S. arenosus and many other organisms.

Over the Grande Grève limestones lie the Gaspé sandstones of Logan, shown in apparently conformable contact with the rocks below at Little Gaspé, and attaining an immense thickness. Sir William estimated them at over 7000 feet and subdivided them largely on lithologic characters, as they vary from drab ferruginous, fine grained quartz and feldspar sandstone to coarse conglomerates and red sandstones, the latter being mostly toward the top. From the lower beds Dawson described many interesting plant remains all presenting the aspect of such sedimentation as characterizes both in New York and Europe the deposits of the Devonic or Old Red lakes or lagoons. The lower beds about Gaspé basin contain a fairly rich marine fauna which has been partly described by Billings and to which we have been able to add evidences of both early and middle Devonic age.

View looking east from the Murailles. Bonaventure Island in the distance, Percé rock and Mt Joli in middle, one of the peaks of the Murailles in the foreground

In the region about Percé the presence of limestones corresponding to those at Gaspé "on the horizon of the Lower Helderberg and Oriskany" [*Geol. Can.* 1863. p.439] was noted by Logan in connection with his rapid but very lucid sketch of the geology of the coast section from Gaspé to the Bay of Chaleurs. Some lists of fossils were given, though these have only in part been verified by subsequent identification, Mr Billings having described a goodly number from the uppermost horizons represented in the Percé rock.



The vertical strata of Percé rock

On analyzing the relations of the various limestones and shale masses exposed about Percé, based specially on the character of the fossils, we shall find in the massives now dissevered either by topography or displacement, the key to their geologic structure not in their apparent relations, their attitude one toward another, but here again, as ever, in the nature of their fossil contents, which in themselves afford the solution to the geologic enigma of the region.

Percé rock massive. The tinted strata of Percé rock, standing almost erect, or according to Logan, overhanging the perpendicular

10° northwardly, are the home of a great profusion of fossils many of which are common to the upper or Grande Grève limestones of Cape Gaspé.

As to the essential concurrence of these faunas in a broad sense there can be no question but the careful comparison of them leaves room for doubt whether the actual horizon of the Percé rock is represented in the series at Grande Grève. Inasmuch as the rock succession of Cape Gaspé is constant as far as it extends there is room for the provisional suggestion that the horizon of the Percé rock with the precise expression of its fauna is there modified, but indicates an early stage of the Grande Grève limestones. Percé rock is not divisible faunally and its strata show no persistent differences. They are indifferently yellow and red according to degree of oxidation, and the process of color change, irrespective of sedimentation lines or structural features, is everywhere finely marked. They are highly veined with calcite seams, and the yellows seem, if anything, to predominate on the south, the reds on the north. Mr Ells speaks of their containing interleaved conglomerates but of such we have seen nothing. We may not at this time give a statement of exact or final determinations of its species, but the following suffices to indicate the character of the fauna. To these we shall hope to return in future with the detailed comparisons needful to ascertain the organic and time relations of this fauna to those of the New York series. Such species as are here indicated with unfamiliar names will be fully defined and illustrated hereafter.

Aulopora *sp.*

Lingula rectilatera *Hall.* As in the Helderberg of New York

L. spathata *Hall.* In the New York Helderberg

L. elliptica *nov.*

Orbiculoidea *nov. cf.* grandis *Hall.* New York Oriskany

Pholidops terminalis *Hall.* Also in New York Oriskany

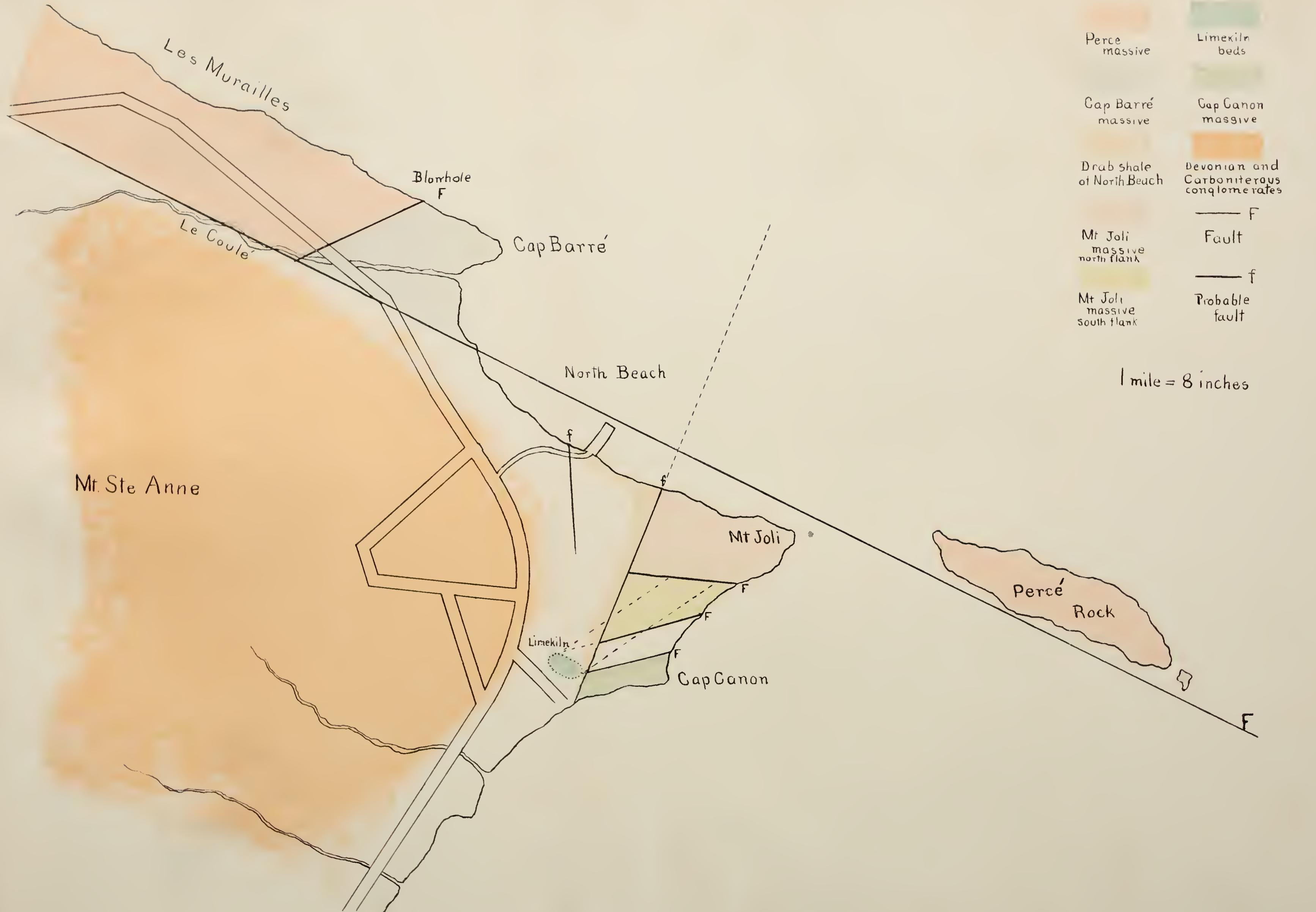
Crania grandegrevensis *nov.*

Leptaena rhomboidalis *Wilckens.* New York Oriskany

Brachyprion majus *Clarke.* Oriskany

Stropheodonta lincklaeni *Hall.* Oriskany

Leptostrophia magnifica *Hall.* As in the Oriskany of New York



GEOLOGICAL MAP OF PERCÉ AND VICINITY

L. irene *Billings*

L. tullia *Billings*

Chonetes antiopia *Billings*

C. canadensis *Billings*. Profusely abundant, much more so than at Grande Grève

C. hudsonicus *Clarke*. New York Oriskany

Chonostrophia complanata *Hall*

Cyrtina affinis *Billings*

Spirifer murchisoni *Castelnau*. This widely distributed Oriskany species is less abundant here than at Grande Grève

S. arenosus *Con*. As S. superbus Billings profusely abundant

S. dolbeli *nov.*

Meristella lata *Hall var.* complector *nov.*

Megalanteris plicata *Hall*

Beachia amplexa *nov.*

Rensselaeria ovoides *Eaton var.* gaspensis *nov. cf.* Oriskany

Leptocoelia flabellites *Conrad*. In enormous masses constituting one of the most abundant of all the fossils. World-wide at this horizon

Actinopteria *cf.* communis *Hall*. In the Helderberg and Oriskany of New York

Megambonia nitidula *nov.* A small form of the type of M. crenistriata (Oriskany)

Trochonema canale *nov.*

Diaphorostoma perceense *nov.* of the type of D. ventricosum (Oriskany) and D. affine (Grande Grève)

Platyceras tortuosum *Hall*. Oriskany species in New York

P. argynus *nov.*

Tentaculites elongatus *Hall*. Also in the Oriskany

T. perceensis *nov.*

Dalmanites (Probolium) perceensis *nov.* This is a really remarkable species both in structure and size. Outside of the Helderberg fauna of New York, it is the only American trilobite having the long and forked cephalic snout characterizing the subgenus Probolium (D. nasutus, D. tridens)

but instead of having the pygidium of those species, which is believed to be marked with a long terminal spine and irregularly pustulose surface, its caudal plate approaches more nearly that of D. micrurus of the same fauna. Fragments of this species are very abundant and some indicate a size greater than that attained by any known species of the genus and indeed by any known trilobite except the colossal Uralichas ribeiroi from the Silurian of Portugal. Restorations from these fragments show that D. perceensis attained a length of 25 inches. It is the only species of the genus present in the fauna.

Phacops logani *Hall*. A Helderberg and Oriskany species in New York

To indicate our present knowledge of the distribution of this fauna, its relation to that of the Grande Grève limestones and the composition of the latter I subjoin the following tabulation to which have also been added the species of the marine fauna of the Gaspé sandstones as developed about Gaspé Basin.

List of Gaspé Devonic fossils

	GRANDE GRÈVE LIMESTONES All localities on north shore of Gaspé bay from Little Gaspé (contact with Gaspé sandstone) to Shiphead	PERCÉ ROCK	GASPÉ SANDSTONE
Glossina acer *nov*	×	....	....
Lingula elliptica *nov*	×	×	....
L. spathata *Hall*	....	×	....
L. rectilatera *Hall*	....	×	....
Orbiculoidea *cf.* grandis *Hall*	×	×	....
O. *sp*	×	....	....
Pholidops terminalis *Hall*	×	×	....
P. *cf.* ovata *Hall*	×	....	....
Crania pulchella *Hall & Clarke*	×	....	....
C. grandegrevensis *nov*	×	×	....
Dalmanella lucia *Billings*	×	....	....
Rhipidomella lehuquetiana *nov*	×	....	....
R. logani *nov*	×	....	....
R. musculosa *Hall*	×	....	....
R. *sp.*	×	....	....
Schizophoria amii *nov*	×	....	....

Photo by L'Esperance

Percé village and rock from the summit of Mt Ste Anne. The headlands of Mt Joli and Cap Canon in the middle distance and the Bonaventure conglomerate of Ste Anne in the foreground

List of Gaspé Devonic fossils (*continued*)

	GRANDE GRÈVE LIMESTONES All localities on north shore of Gaspé bay from Little Gaspé (contact with Gaspé sandstone) to Shiphead	PERCÉ ROCK	GASPÉ SANDSTONE
Hipparionyx proximus *Vanuxem*	×	....	....
Orthothetes woolworthanus *Hall mut.* gaspensis	×	....	....
O. becraftensis *Clarke*	×	....	....
Leptaena rhomboidalis *Wilckens*	×	×	....
Stropheodonta parva *Hall mut.* avita *nov.*	×	....	....
S. crebristriata *Hall mut.* simplex *nov.*	×	....	....
S. patersoni *Hall mut.* praecedens *nov.*	×	....	....
S. galatea *Billings*	×	....	....
S. hunti *nov*	×	....	....
S. lincklaeni *Hall*	×	×	....
S. magniventer *Hall*	×	....	....
Brachyprion majus *Clarke*	×	×	....
Leptostrophia magnifica *Hall*	×	×	....
L. blainvillii *Billings*	....	....	×
L. irene *Billings*	×	×	....
L. oriskania *Clarke*	×	....	....
L. tullia *Billings*	....	×	....
Strophonella continens *nov*	×	....	....
equiplicata *nov.*	×	....	....
senilis *nov*	×	....	....
equalis *nov*	×	....	....
ampla *Hall*	×	....	....
Chonetes canadensis *Billings*	×	×	....
C. melonicus *Billings*	×	....	....
C. antiopia *Billings*	×	×	....
C. hudsonicus *Clarke*	×	×	....
mut. gaspensis *nov*	....	....	×
C. billingsi *nov*	×	....	×
C. *sp.*	×	....	....
Chonostrophia complanata *Hall*	×	×	×
C. dawsoni *Billings*	....	....	×
Anoplia nucleata *Hall*	×	....	....
Spirifer arenosus *Conrad*	×	×	....
S. murchisoni *Castelnau*	×	×	....
S. gaspensis *Billings*	....	×?	×
S. dolbeli *nov*	×	×	....
S. modestus *var.* nitidulus *nov*	×	....	....
S. fimbriatus *Conrad*	×	....	....
S. ? hera *nov*	....	....	×
S. *sp.*	×	....	....
Cyrtina rostrata *Hall*	×	....	....
C. affinis *Billings*	×	×	....
Meristella lata *Hall var.* complector *nov.*	×	×	....
M. acerra *nov*	×	....	....

List of Gaspé Devonic fossils (*continued*)

	GRANDE GRÈVE LIMESTONES All localities on north shore of Gaspé bay from Little Gaspé (contact with Gaspé sandstone) to Shiphead	PERCÉ ROCK	GASPÉ SANDSTONE
Rhynchospira	×	....	....
Coelospira concava *Hall*	×	....	....
Nucleospira *cf.* ventricosa *Hall*	×	....	....
Camarotoechia dryope *Billings*	×	....	....
C. excellens *Billings*	×	....	....
C. ramsayi *Hall*	×	....	....
Plethorhyncha barrandei *Hall*	×	....	....
P. pleiopleura *Conrad*	×	....	....
Uncinulus mutabilis *Hall*	×	....	....
Eatonia peculiaris *Conrad*	×	....	....
Beachia amplexa *nov*	×	×	....
Megalanteris plicata *nov*	×	×	....
Rensselaeria ovoides *Eaton var.* gaspensis *nov*	×	×	×
R. *sp*	×	....	....
Cryptonella ? capsa *nov*	×	....	....
C. ? fausta *Clarke*	×	....	....
Leptocoelia flabellites *Conrad*	×	×	×
Centronella glansfagea *Hall*	×	....	....
Aviculopecten perceus *nov*	....	×	....
A. ? incrassatus *nov*	×	....	....
Pterinopecten proteus *Clarke mut*	×	....	....
Actinopteria communis *Hall*	×	×?	....
A. textilis *Hall*	×?	....	....
Megambonia crenistriata *Clarke*	×	....	....
M. nitidula *nov*	....	×	....
Palaeopinna flabellum *Hall*	×	....	....
Modiella modiola *nov*	....	....	×
M. pygmaea *Conrad*	....	....	×
Goniophora mediocris *Billings*	×	....	....
Leptodomus canadensis *Billings*	×	....	....
Modiomorpha gaspesia *nov*	×	....	....
Mytilarca nitida *Billings*	×	....	....
M. canadensis *Billings*	×	....	....
Cypricardinia distincta *Billings*	×	....	....
Phthonia cylindrica *Hall*	....	....	×
Nuculites gaspensis *nov*	....	....	×
Conocardium cuneus *Conrad*	×	....	....
Schizodus ventricosus *Billings*	×	....	....
Bellerophon plenus *Billings*	×	....	....
B. gaspensis *nov*	×	....	....
Tropidodiscus wakehami *nov*	....	....	×
T. pelicea *nov*	....	....	×
Pleurotomaria delia *Billings*	×	....	....
P. voltumna *Billings*	×	....	....
P. lydia *Billings*	×	....	....
P. ? rotula *nov*	×	....	....
Trochonema canale *nov*	....	×	....
Loxonema ? hebe *Billings*	×	....	....

List of Gaspé Devonic fossils (*concluded*)

	GRANDE GRÈVE LIMESTONES All localities on north shore of Gaspé bay from Little Gaspé (contact with Gaspé sandstone) to Shiphead	PERCÉ ROCK	GASPÉ SANDSTONE
Euphemus ? quebecensis *nov*	....	....	×
Holopea gaspesia *nov*	....	....	×
H. depressa *nov*	×	....	....
H. *cf.* antiqua *Hall*	×	....	....
Diaphorostoma affine *Billings*	×	....	....
D. desmatum *Clarke*	×	....	....
D. perceense *nov*	....	×	....
D. *sp*	×	....	....
Strophostylus expansus *Hall var*	×	....	....
Platyceras gaspense *nov*	....	....	×
P. argynus *nov*	×	×	....
P. eucerus *nov*	×	....	....
P. laciniatum *nov*	....	....	×
P. tortuosum *Hall*	×	×	....
P. conulus *nov*	×	....	....
P. paxillatum *nov*	×	....	....
P. *cf.* nodosum *Conrad*	×	....	....
P. *cf.* fornicatum *Hall*	×	....	....
P. *sp.*	×	×	....
Hyolithus oxys *nov*	×	....	....
H. encentris *nov*	×	....	....
H. *cf.* aclis *Hall*	....	....	×
Conularia lata *Hall mut*	×	....	....
C. desiderata *Hall*	×	....	....
Orthoceras *sp*	×	....	....
Cyrtoceras *sp*	×	....	....
Kionoceras rhysum *nov*	×	....	....
Dalmanites micrurus *Green*	×	....	....
D. phacoptychoides *nov*	×	....	....
D. pyrene *nov*	×	....	....
D. vatinius *nov*	×	....	....
D. goniaea *nov*	×?	....	....
D. foederatus *nov*	×	....	....
D. (Probolium) perceensis *nov*	....	×	....
Phacops bombifrons *Hall*	×	....	....
P. logani *Hall*	....	×	....
P. correlator *Clarke*	....	....	×
Proetus phocion *Billings*	×	....	....
Cordania	×	....	....
Ceratocephala gaspesia *nov*	×	....	....
Lichas (Terataspis) grandegrevensis *nov*	×	....	....
Tentaculites elongatus *Hall*	×	×	....
T. cartieri *nov*	....	....	×
T. perceensis *nov*	....	×	....
Spirorbis latissimus *nov*	×	....	....

It will be seen from the foregoing that the Percé fauna is more sparse than that of Grande Grève and that some of the species extremely abundant there, e. g. Eatonia peculiaris, Hipparionyx proximus are absent here, while here Chonetes canadensis, Leptocoelia flabellites are profusely developed. Again striking species in each fauna are absent in the other, while there remains a number of most characteristic species common: Rensselaeria ovoides var., Me-

The ragged sky line of the Murailles

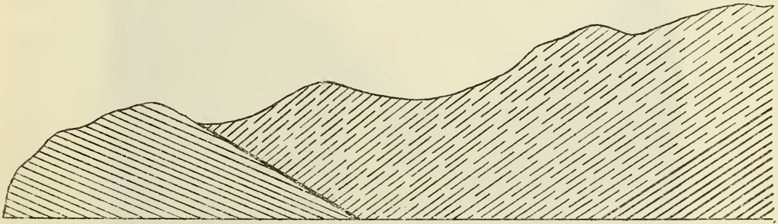
galanteris plicata, Beachia, Spirifer arenosus, S. murchisoni, etc.

There is thus a difference in the relation of the elements of the faunas to each other and also to those of New York. Hence there may be in these faunal characters a reason for regarding these limestones as the expression of a distinct substage in the deposition period of the Grande Grève beds.

On the Murailles or the high rock wall above the North cove we find Percé strata again. Rounding Cap Barré where the dip of the gray limestones and shales is to the north, beyond the first point to

On the slope of the Murailles. The Percé rock strata in the cliff

the Blowhole, a sea cavern gnawed out by the waves, the tinted Percé strata again appear, but here lying at a steep angle, 20° to 40° to the southeast and abutting palpably against the thrust plane of a fault which is well marked in the face of the cliff, sloping obliquely downward and to the north. The line of displacement is well enforced by the contrast in color between the downthrown yellow and red strata and the more somber grays of the Cap Barré massive. Logan noted the fact that these downthrown strata were of equivalent age and probably a part of the Percé rock, and Ells cites the occur-



Section at Blowhole. Cap Barré beds at left, downthrown Percé beds at right

rence in the rocks at the Blowhole of the fossils Spirifer arenosus and S. cyclopterus (probably S. murchisoni); we have also found

Dalmanites perceensis	Leptocoelia flabellites
Phacops logani	Leptostrophia irene
Acidaspis *sp.*	Chonetes hudsonicus
Megalanteris plicata	Spirifer arenosus
Chonetes canadensis	S. murchisoni

and a few others, but the specimens are not very well preserved nor are they in any wise so abundant as at Percé rock.

These Percé beds about the Blowhole are probably again downthrown in themselves in their further extension along the Murailles but without essential change of dip, for this same southward dip is well expressed in the angle of the landward slope of the cliff and is apparent as far as Le Coulé on Barré brook where Percé fossils were also found. The latter seem to be the summit beds of the limestones and from them the following species were obtained.

Spirifer arenosus	Megalanteris plicata
S. murchisoni	Leptostrophia irene
Chonetes canadensis	Coelospira
C. hudsonicus	

The beds are gray and nodular with redder strata. The outcrop is in the strike and the beds apparently rise uniformly into the Murailles. A displacement is evident along the bed of the brook but its amount was not estimated. Red peak, which is the highest and easternmost of the Murailles, is said by Logan to

Le Coulé. Nodular limestones and limestone conglomerate

be capped by horizontal beds of "the conglomerate" which I take to mean the conglomerate of Mt Ste Anne (Bonaventure) but I was not able to verify the observation, the beds here being apparently conformable in dip to those below. The displacement of the tinted Percé strata (the term Percé is here used as indicative of the horizon of the Percé rock) against the Cap Barré beds is evident on the south road leading up the mountain side to

the Grand Coupe, as well as in Le Coulé as just stated. In the great sea front of Red peak, the high face rising 660 feet over the water is believed to bring up the lower gray limestones in conformity and, though these beds are difficult of access and have not been properly studied, it is likely that here are the strata which fill the broken interval between the Percé beds and those beneath, the rocks of Cap Barré and perhaps also in part those of Cap Blanc.

As a whole, we may say of the Percé beds that though they are now but remnants left by recent rapid and profound changes in topography, due to the tremendous destructive energy of the sea, and their surfaces, both on the Percé rock and in the Murailles, are the slopes of lost mountains, yet they have been subjected to disturbances in themselves much greater and much more ancient, witnessed by their difference in inclination and their tremendous displacements. These displacements we shall endeavor to portray more particularly in summing up the evidence relating to the geologic structure of the region.

There is little evidence yet on which to base any kind of subdivision of the Percé rock mass, either from its fossils or its rocks. The yellow beds seem to bear in greater abundance the prolific species Chonetes canadensis, Leptostrophia irene, Chonostrophia etc., and the red layers the trilobite remains, Spirifer arenosus, S. murchisoni, etc., but this occurrence is open to constant exception.[1]

Cap Barré beds. In first considering the limestones of Percé rock we have started with the latest of the limestone deposits. In close if not immediate succession beneath them seem to follow the gray schists exposed only at Cap Barré, the southernmost and lowest point of the Murailles.

These beds consist of thin, sandy, blue gray limestones with intercalated shale, the rock becoming reddish at the top beneath the soil cap. They dip northeast 30° to 40°, which is an angle not repro-

[1]Most of the fossils from the Percé rock described by Billings were evidently picked up loose at the foot of Mt Joli whither they are washed in great quantity from the rock itself. Hence Billings, not personally acquainted with the situation, frequently cites Mt Joli as a locality of these fossils which is misleading for the Joli mass is of very different age.

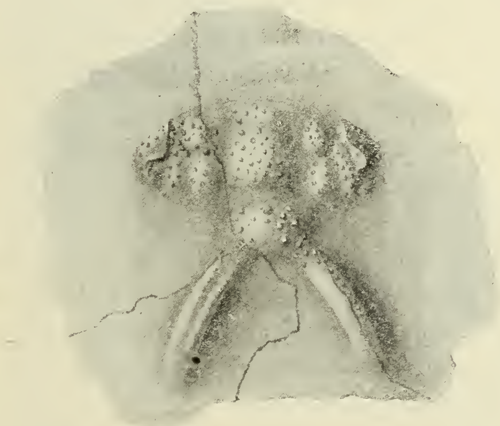
duced in any of the strata elsewhere exposed, and their attitude toward the Percé strata farther north has just been expounded, from which we may infer that these rocks are normally subjacent to the latter and have been separated therefrom by the downthrow of the superjacent mass. These Cap Barré beds, so far as exposed, may attain a thickness of 75 to 100 feet. Their relations with the strata at Mt Joli are determinable from no structural relation exhibited, for they are separated from the latter by the long interval of the

Cap Barré from North cove

North cove. These beds contain fossils, but very sparsely. I have found a few Lingulas and an Ambocoelia-like brachiopod probably allied to Spirifer modestus Hall, which is a Helderberg species, also a small corrugated Leptostrophia like L. oriskania Clarke, but the age and position of the strata are decisively indicated by the presence of a species of the trilobite *Dicranurus*.

This fossil is of more than ordinary interest. The genus Dicranurus has been described heretofore only from two geologic formations, the Helderberg (New Scotland beds and Coeymans

limestone) of eastern New York (D. hamatus Conrad) and from the equivalent horizon Etage G, of Bohemia (D. monstrosus Barrande sp.). The species from Cap Barré (D. limenarcha) is represented only by an incomplete cephalon but it is rarely that any other part of the genus has been observed in any of its occurrences. It was a species larger than the New York form and perhaps even larger than the Bohemian. Its elongate, subconate middle lobe is well delimited by a deep nuchal furrow, the lateral lobes are separated by a shallow transverse or oblique groove, while the axial diameter of the occipital ring from the base of the



Dicranurus limenarcha

central lobe to the fork of the spine is relatively less than in D. hamatus. The free cheeks were attached to this specimen, but they have not been preserved except along the sutures. The great neck spines are highly divergent and very heavy. Barrande gave the angle of divergence in D. monstrosus as 60°, in D. hamatus it is 45°, in D. limenarcha it is 80°, measured from the central occipital tubercle as apex, axially for one third of the length of the spines. These spines are curved outward, downward and back, and probably made a deep recurvature as in the other species, though they are not preserved at the tips. On their proximal extent is a low median depression. The surface of the head is covered with acute pustules scattered sparsely with very much finer

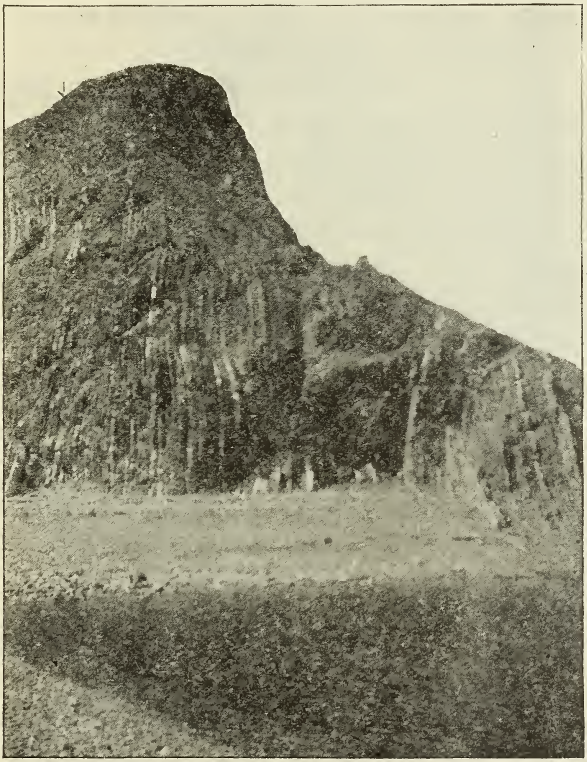
ones between. On the occipital ring the central pustule, which is more conspicuous than the rest as in other species, is punctuated at the top by a circle of depressions. The head had an original length to the point of recurvature of the neck spines of about 40mm, the greatest divergence of the spines is 29mm, the axial length to the angle of the spines, 23mm, of which 9mm belong to the occipital ring; width between the eyes, 25mm.

From no other evidence have we so satisfactory a basis for the conclusion that the Cap Barré beds follow close below the beds of Percé rock and above those of Mt Joli. We may therefore conclude that either these strata lie buried in the tide-swept interval between the Percé rock and the outermost vertical strata belonging to the Mt Joli massive, or that, originally in place here, they have been pinched out by faulting.

The space between these two massives not in the line of the connecting sand spit but rather in the line of vertical thickness of the strata, at right angles to their present position, is barely enough to admit the beds of Cap Barré. Doubtless they have been largely squeezed out in faulting and pitched over on their side where they now lie, though some part of them may remain in the interval, to be exposed by some favoring neap tide to the eye of the trained observer.

Shales of the North beach. Faintly exposed at spots in the bank along the North beach, in the dugway road to the wharf and at points from there toward Mt Joli are beds of soft shale usually gray, sometimes black, blue black and green black, lying under the reddish soil cap. These are slightly inclined away from the vertical and it is not in my present judgment at all certain that they are continuous with the Joli escarpment which we are about to consider. They have furnished no fossils and outside of them, beneath the water not far from the wharf, is a vertical reef in which cyathophylloid and favosite corals occur and these are doubtless the latest and uppermost beds of the Joli series. Soft drab shales similar to those on the North beach appear also in the roadway between the Cap Canon cliff and the escarpment at Lamb's limekiln, and I have inferred therefrom the presence of an infaulting through which this mass of shales has been displaced from its proper position.

Mt Joli massive. The erect strata of gray thin limestones and calcareous shales which constitute the low headland at Mt Joli begin not at the scarp itself, but at low water may be seen extending well out from the shore. Along the North beach these outlying strata form little reefs, but the intervals between them and the wall of the promontory is concealed by the beach. Taking the Mt Joli massive



East face of Mt Joli

as a whole, it has an approximate length along the sea front of 700 feet, the highest point being at the north, the upper slope declining southerly, ending rather abruptly, and the rock mass being separated from that of Cap Canon by an unexposed and probably entirely interrupted area of about 350 feet. There is little change in the lithologic composition of the strata composing Mt Joli, but there is definite evidence of displacement in the mass itself. For the greater

part of the length of the sea wall the strata are essentially vertical with slight undulations; but at a distance of about 250 feet from the south end of the cliff the strata become much more irregular, maintaining their essentially vertical attitude but are folded and slightly displaced among themselves and faulted against the more erect strata of the main part of the mountain. The southern part of the mass is composed of strata similar to those of the northern but increasingly slaty in composition. In both parts of this Mt Joli massive fossils were found, but they are by no means of common occurrence; moreover they are wedged in the vertical strata so that their extraction is not easily accomplished. From their calcareous layers, which with the eroded interleaved shales form the outermost northern reach of the strata and are exposed only at low tide as reefs, were obtained a few fossils: Platyceras, large species of Helderberg type; Zaphrentis corticata Billings; Z. cingulosa Billings.

The shaly layers on the high vertical north face of the scarp have afforded species provisionally identified as follows:

1 Hindia *sp.*
2 Monograptus *cf.* clintonensis *Hall*
3 Duncanella *cf.* borealis *Nich.*
4 Streptelasma *cf.* caliculus *Hall*
5 Michelinia *cf.* lenticularis *Hall*
6 Dalmanella *cf.* perelegans *Hall*
7 Leptaena rhomboidalis *Wilckens*
8 Stropheodonta *cf.* varistriata *Conrad*
9 Spirifer *cf.* niagarensis *Conrad*
10 Spirifer modestus *Hall?*
11 Cypricardinia *aff.* sublamellosa *Hall*
12 Phacops *sp.*

Giving special attention to the trilobite in which lies the clearest indication of geologic age, we find it to be a fully developed Phacops such as nowhere occurs in the typical Siluric deposits of the Mississippian sea or Appalachian gulf. Its glabella is large, rotund and coarsely pustulose, the glabellar furrows obsolete, eyes large and the genal angles have minute spinules. The pygidium is broad, the axis having six to eight well defined rings, the first bearing a prominent tubercle, the pleurae having five to six ribs all grooved and separated by deep furrows. These structural points indicate an early period in the history of the genus, hence if Siluric, a final stage. The species is equivalent to Phacops logani of the Helderberg and Oriskany of New York, of the Percé rock and the Grande Grève limestones.

The Murailles and North cove, looking toward Malbay

The construction of this assemblage as a whole as indicative of a very late upper Siluric marine fauna is justified and we would therefore put together the entire mass of the strata 550 to 600 feet thick, as appertaining to this horizon, that is the series of limestones and shales extending from the reefs bordering the north flank of Mt Joli, southward almost to the first palpable shear zone.

In the layers of the south flank of the mountain which strike n. 30° w., are essentially vertical but with many undulations and irregular inclinations toward the north, and are thin, fairly pure limestone strata from 2 to 5 inches in thickness separated by sandy shale masses, fossils have been found:

Hindia (apparently identical with foregoing)
Subretepora
Dalmanella testudinaria *Dalman*
Rafinesquina *sp.*
Strophomena *sp.* strongly geniculate form (very common)
Parastrophia hemiplicata *Hall* small form
Zygospira *cf.* uphami *Winchell & Schuchert*
Ortonia *sp.*
Ampyx hastatus *Ruedemann*
Tretaspis reticulatus *Ruedemann* (very common)
Calymmene callicephala *Green*
Pterygometopus *cf.* intermedius *Walcott*
Ptychopyge ulrichi *Clarke* (common)
Illaenus americanus *Billings*

This very striking though small array of species is emphatically indicative of early Siluric age, we might say in a general sense equivalent to the Trenton, but can not escape the inference that it is early Trenton with suggestions of Pretrenton age. The trilobites are specially noteworthy, for Ampyx hastatus and Tretaspis reticulatus have been found before only in the lower Trenton conglomerate of Rysedorph hill near Albany and definitely indicate not the Trenton fauna normal to the Mississippian province of that time, but the invading fauna from the Atlantic province whose closer affiliations are with European species.

Two spots in the sea wall have afforded these fossils, one not far from the south end of the cliff where were taken

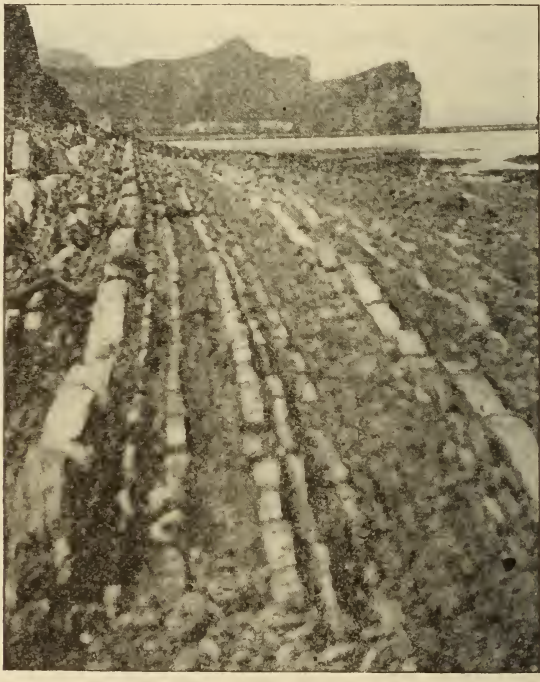
Calymmene callicephala
Dalmanella testudinaria
Rafinesquina
Parastrophia hemiplicata
Zygospira

These were from calcareous nodules embedded in the shales.

The other locality lies just north of the most apparent line of displacement where the strata have lost their contortions. Here were obtained

Tretaspis reticulatus	Illaenus americanus
Ampyx hastatus	Pterygometopus *cf.* intermedius
Ptychopyge ulrichi	

It is not safe to infer great difference in age of these associations.

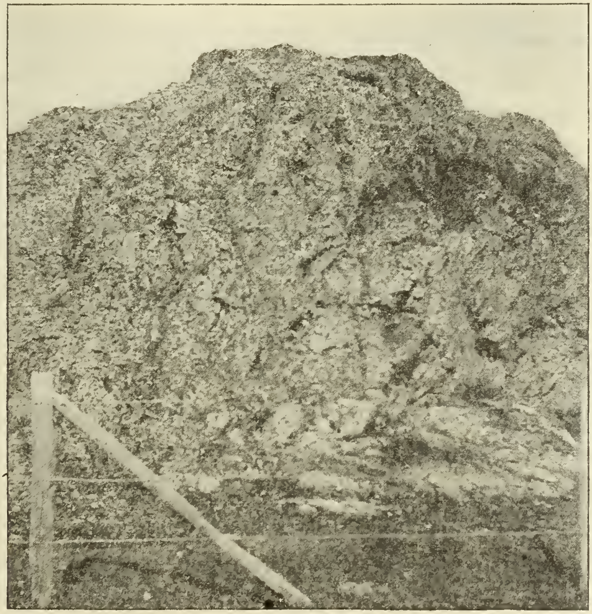


Vertical strata on north face of Mt Joli. The Murailles in the distance

Mt Joli then with its 700 feet of calcareous strata represents a long stretch of Siluric time, and it would appear that the apparent line of main faulting of the southern or lower against the northern or upper mass, marks the disappearance of some interval in the lower elements of the series as indicated. Such departure as there has been from the vertical position of the strata is in the direction of overthrow so that the lower lean up against the higher strata.

We shall presently note the paleontologic evidence indicating displacement in the vertical mass itself.

Cap Canon massive. Directly south or below the abrupt termination of Mt Joli is a beach interval where no rock exposure is seen for a length of 345 feet. The grass grown bank shows a red soil cap and in it here and there are blocks of red conglomerate, as though (and to such evidence we may return) deposition of the red conglomerates was over a rough bottom wherein this clay-banked beach was a deeply gullied line of disturbance. The rocks of Cap Canon are calcareous shales and black argillaceous slates, greatly



The Limekiln massive

disturbed internally by folds and undulations, thrusts of slight measure which have produced glistening shear faces, veined in all directions, richly jointed and cleaved, but in spite of these internal displacements the vertical attitude of the mass is still apparent with a slight general inclination toward the north.

This mass, irrespective of its undulations has a sea front 630 feet long and this is approximately a measure of its actual thickness. In lithologic character there is a marked difference between it and that of Joli, chiefly expressed in its slatiness. It has, after repeated search, revealed no fossils.

On the summit of Cap Canon is the summer home of Mr Frederick James. From this spot the well grassed rock surface slopes deeply landward, then abruptly rises at a distance of about 400 feet from the edge of the cliff and the strata stand upright again in a bare dome of rock at which is a now abandoned limekiln. The rock here was burned by Mr Philip Le Boutillier and from him I learn that the burning has been only partly successful but at times a purer limestone has been brought to the kiln from the outcrops at Cap Blanc, 2 miles south.

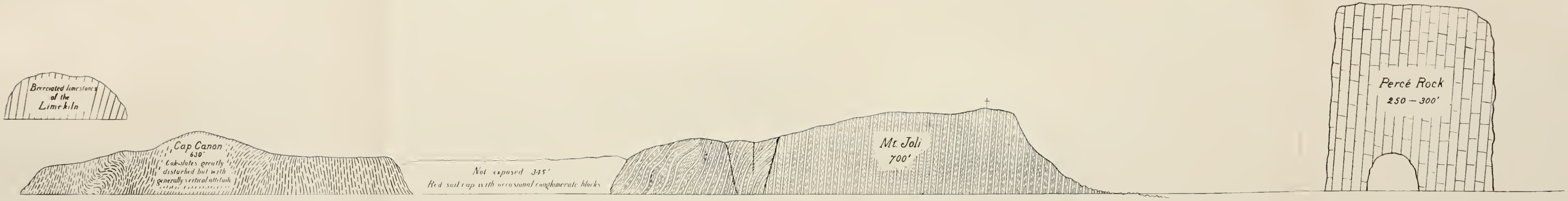
Limekiln massive. The rocks at the Limekiln are as a whole notably distinct in character from those constituting Cap Canon though they stand vertical and hold the attitude characterizing the rest of the strata.

These beds are limestones much seamed with calcite veinules and heavy bedded, largely a limestone conglomerate but with no jasper pebbles as in the limestone conglomerate of Mt Ste Anne to which reference will be made. They have a thickness of 200 feet. A single bed of a similar conglomerate was observed infolded in the schists of Cap Canon.

Just beneath these on the south slope are even bedded impure gray limestones and from these latter only have fossils been obtained. There is to my mind a reasonable security in regarding these fossil-bearing rocks here in place, though blocks have been found only in displaced condition. Concerning this point, however, I would not venture to be unqualified in my statement. These fossils are:

Plectambonites sericeus *Sow.* (very common)
Rafinesquina, a geniculated species
Leptaena rhomboidalis *Wilckens*
Protozyga exigua *Hall*
Ambonychia *sp.*
Ceraurus pleurexanthemus *Green*

Though few in number, the species abound in individuals and the assemblage clearly indicates a later stage of Lower Siluric than the fauna in the south flank of Mt Joli, somewhere equivalent to middle or upper Trenton age. The road in front of Mr James's house, as it rises from the depression between the escarpment and Cap Canon, shows trace of an infaulted mass of soft, brown shale elsewhere referred to as occurring on the North beach near the wharf. If we



SECTION ALONG THE COAST FROM ROBIN BEACH TO PERCÉ ROCK

have construed the fauna correctly, the place of the Limekiln rocks is between the south and north flanks of Joli or is a corresponding portion in the series. We may find no clear evidence of the necessary fault plane in that escarpment, but this cliff at the Limekiln is evidently cut off by faults both therefrom and from the Cap Canon mass.

Cap Blanc massive. From Cap Canon southward for a distance of 2 miles sweeps, first, the broad Robin fishing beach or South cove buttressed at the south by horizontal or slightly dipping beds of red sandstone and conglomerates rising into a constantly more elevated sea wall till Cap Blanc is reached. Here as one turns the point of the headland and rounds the light, vertical limestone strata are once more exposed and their contrast in color to the horizontal or slightly northeast dipping red strata which overlie them and abut against their slopes, gives name to the place. The sea wall is sheer and the foot of the cliff accessible with risk, even by water.

The vertical thickness of these rocks measuring from the point of the cape southward is estimated at 700 to 1000 feet. They are light gray in general effect and the succession of the strata is obscurely presented in the highway and field outcrops. With the slight inclination of the strata away from the vertical toward the north as seen in the Mt Joli massive, we first find in the highway cut ascending the cliff from the north a red limestone, suggesting in tint the Percé rock and carrying

Halysites catenulatus *Linné*	Bellerophon
Heliolites or Lyellia	Lichas (fragment)
Ortonia	Trematopora (very slender branches)
Anodontopsis	Callopora
Trochonema	Small Whitfieldella-like brachiopods

but principally and oftenest a large and heavy shelled pelecypod having a broad cardinal plate extending inward from the hinge line, not attached to the bottom of the valves nor thickened at its junction therewith. This rock is of such character that it breaks in almost any direction except along the surface of these fossils but one example of this species has the valves together and this, sectioned vertically shows these projecting plates not in apposition as though

connected with the articulation of the valves, but standing apart with a well defined space between, indicating that they are a broad chondrophore. Further material will be necessary to elucidate the nature of this shell.

It is clear however, from the list given, even though generic determinations only seem safe at present, that this congeries represents a stage of late Siluric, clearly older than the fauna of the Percé rock, probably older than the beds of Cap Barré, but not necessarily older than the north flank of the Mt Joli massive. These beds, the highest in the series, lie lowest as the entire mass is slightly overturned. Working southward over the remaining exposures in exceedingly rainy and cheerless weather, it is probable that we have overlooked much that will throw light on the relations of the series.

Beyond the light, seaward of the road, on the edges of the escarpment in the field whence the purer layers of limestone have been removed for burning, and which appertain to the lower and southernmost part of the series here represented, after careful search fossils were found, not in the blue and more abundant limestone, but in thin clinking limestone plates.

The mode of preservation here is singularly favorable were the material sufficiently abundant, the fossils being weathered out on the surfaces of the plates and doubtless the fauna will prove an interesting and instructive one under more favorable opportunities for exploration. These slabs have afforded:

Spicules of hexactinellid sponges	Whitfieldella *cf.* bisulcata
Platyostoma	Orthothetes (small)

Many crinoid stems and an occasional crushed head with ornamented plates resembling Glyptocrinus.

Calymmene (small species)	Phacops of P. logani type
Bumastus (small species)	Phacops *sp.*

Taking up for more minute consideration the trilobites, the time values of whose structure is best understood, we may note

1 The common species of Phacops is fully developed, with glabellar lobes fused by almost entire disappearance of the furrows, eyes rather small, cheeks rounded with the faintest trace, if any, of the genal spinules indicating early age, and the doublure of the cephalon

crenulated to a degree shown only in pronounced development in this genus.

The pygidium is short and stout with a short blunt axis bearing four defined rings but eight axial sulci can be counted. Of the pleural ribs but two can be counted and these are flat and sulcate.

This completely developed Phacops is in itself indication of either Devonic age or a very late stage of Siluric. In the Mississippian Siluric no such form presenting fully matured cephalic features is known. The species, however, shows in the sulcate pygidial ribs index of early phylogenetic stage. It can not be identified with the Helderbergian and Oriskany P. logani which is found in the Percé rock and at Joli, but approaches thereto.

2 The second species of Phacops is known only from its cephalon which is of a singular and unusual type. In this the first furrows of the glabella are faint without entering the dorsal furrows and are like a pair of eyebrows, defining obscure round lobes, behind which the second lobes are also round and better defined, while the third lobes are obscure. The eyes are small and with few lenses, the cheeks broad, flat and dalmanitiform, running out into short flat spines at the angles.

The aspect of the species is that of immaturity with reference to the development of the genus Phacops and presents the combination with features pertaining to Dalmanites which is indicial of the passage forms from the latter to the former. The aspect of this cranidium is shown in some early Devonic forms such as P. (D.) tumilobus Clarke from the Amazonas but without association with cheeks of notable Dalmanites type.

One of these forms of Phacops indicating late age is counterbalanced by the somewhat earlier expression of the other and this combination is verified by the presence of Bumastus and Calymmene.

We must call the horizon late Siluric but are disposed to make it so late as to be an almost final stage in the passage from the lower limestones into those of the Percé massive or lowest lower Devonic.

The Cap Blanc limestones appear then from the evidence before us to be a downthrown mass representing a part of the series shown more continuously in the sea wall at Percé, and indeed such part as

is either not there clearly presented or is presented here with some change of faunal association. It is not, in our view, a section of the series there lost by faulting out, but the expression of the later Siluric beds there, with a variant geographic association of species.

Relations of limestone masses about Percé. We have estimated roughly the thickness of the masses here discussed as follows:

Percé beds, 250 feet at Percé rock but probably rising in red peak to	400 feet
Lost interval between Percé rock and Mt Joli (Cap Barré beds)	100-200 feet
Mt Joli massive	700 feet
Cap Canon massive	630 feet
Limekiln massive	200 feet
	2030-2130 feet

Thus there is a development of approximately 2000 feet of limestones representing the geologic series from early Siluric (Black River-Trenton) to well into the early Devonic or Oriskany. The Cap Blanc massive with a thickness of 700 to 1000 feet is not in our judgment an addition to, but a repetition of a part of the series. The rocks on the Murailles are likewise regarded as not adding to, but repeating the series in part, with the exception of the Cap Barré beds which are partially provided for in the rock interval between Mt Joli and the Percé rock. In order of succession from the top downward, we should, from present evidence arrange the masses thus:

Percé beds	(?) Limekiln beds
Cap Barré beds	Mt Joli (south flank)
Mt Joli (north flank)	Cap Canon

Some doubt will attach to the proper position of the strata of the Limekiln for the reasons already stated.

With the foregoing succession we deduce a profound displacement between the Percé rock and the north face of Mt Joli by which the beds of Cap Barré for a thickness of 100 or more feet were squeezed out, and their remnant overturned to their present place and attitude, a quarter mile away, and their dip reversed.

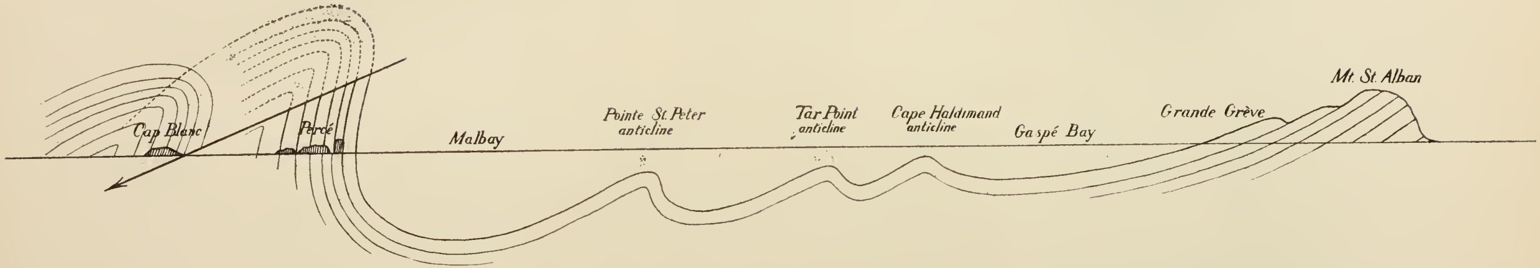
Looking south from Mt Joli, Cap Canon in left foreground, Mt Ste Anne at the right

On the face of Mt Joli among the vertical strata we believe it probable that a displacement has taken place by a downthrow which has squeezed out the rocks represented by the fauna found in the beds at the Limekiln. This is inferred wholly from the nature of the fossils of the latter. Their place is here in the succession of the faunas, but should subsequent developments tend to show that the fossils there found were derived from another source, either from the rocks of Cap Blanc or the limestones northward toward the Barachois, we need not open the cliff to admit this mass. On the other hand, were such the evidence, it would seem to be the remnant infaulted by a displacement whose zone rests where now is the short beach between Joli and Cap Canon.

The displacement we have already noted in the south flank of Mt Joli and shown in the rock wall is within the succession of lower Siluric faunas, these fossils occurring on both sides, and we hence infer it not to have been of great depth.

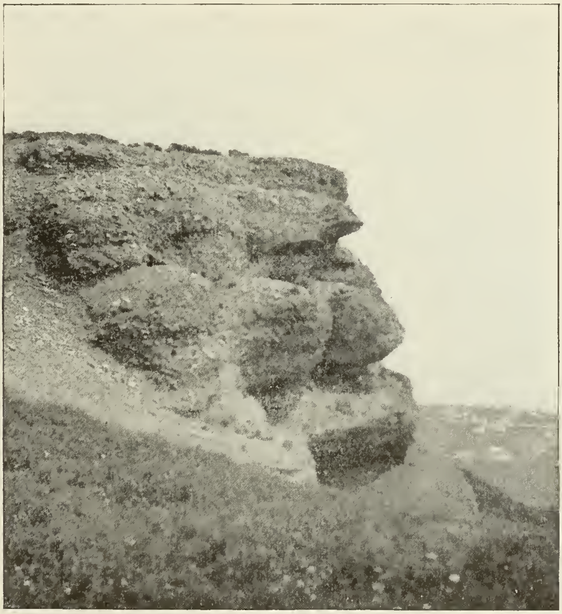
On the Murailles we find the clearly defined line of displacement along which the Percé beds have slipped down over the Barré beds inverting their dip, and this entire mass of Barré and Percé beds was evidently cut off by the longer line of faulting from the Percé rock. These lines of probable displacement of the limestone masses we have expressed on the map adjoining.

Surface conditions preceding deposition of red sandstone and conglomerates. Strip off the mantle of red, almost horizontal conglomerate through which the limestone cliffs project their heads and the country would present an irregular series of jagged limestone bluffs, the remnants of broken and eroded folds, which the tooth of subaerial weathering, of stream erosion and the endless gnawing of the ocean, left standing. The vertical position of most of those once horizontal rocks is in itself an indication of the immense proportions attained by the primary folding of the strata. The presence of an anticline at Percé was recognized by Logan, and without venturing to go so far afield as to connect the structures here with those beyond the scope of this sketch, it may be said that the simplest explanation of the relation of the Percé limestones with the series as exhibited from Little Gaspé to Shiphead is a great syncline beneath the sea, of



Restoration of the syncline in Devonic and Siluric limestones along coast line from Percé at the south to Grande Grève at the north and showing the downthrow at Cap Blanc; also the anticlines riding on this depression and more clearly expressed farther inland

which the Grande Grève limestones lie on the northern more gradually sloping arm and the Percé rock on the southern erect arm. With this reconstruction, the massive of Cap Blanc represents the faulted downthrown crest of the Percé fold, while lesser anticlines indicated by the government geologists as those of Pointe St Peter, Tar point, Cape Haldimand, developed further back from the coast, ride on the surface of this synclinorium.



Bonaventure conglomerate at summit of Mt Ste Anne

Immense time was necessary for the destruction of these old folds before the ragged country was carried down beneath the water level for the deposition of the red conglomerates and sandstones.

Red sandstones, conglomerates and limestones

The country is so completely sheeted with these horizontal deposits that they may be studied at numerous places away from the limestone cliffs, but nowhere in their continuity so well as along the slopes of Mt Ste Anne. Let us however, first take note of the opinions which have been expressed by Logan and Ells concerning these

deposits. We have remarked that while almost horizontal, there is a definite dip in the strata to the northeast which is conspicuously displayed in the precipitous eastern face of Mt Ste Anne, and in the western wall of the distant Bonaventure island, 3 miles out to sea. From Bonaventure island, which is wholly composed of these strata, Logan derived the term Bonaventure which he originally applied to the entire series of these rocks, chiefly conglomerates, and these he regarded as of Carbonic age. Ells, approaching the region from a study of the conglomerates of the Bay of Chaleurs interstratified in which have been found Devonic fossils (chiefly fishes of Old Red sandstone type) recognizes differences in the conglomerate mass and assigns to the Bonaventure the upper beds of Mt Ste Anne and all those covering Bonaventure island with which they were continuous, believes an unconformity to exist between the upper and lower conglomerates of Mt Ste Anne and assigns the latter including the sandstones and interbedded limestones, to the Upper Devonic age. Of such interruptions of deposition in the conglomerates we could find no evidence in the Percé region but if we interpret these interesting sediments aright, it is quite in accordance with the judgment we have been able to form, that they do actually represent a period of time partly Devonic but transcending that era into the next succeeding. We may note the character of these strata in some detail, beginning at the lowest accessible exposures.

Shore between Robin beach and Cap Blanc. Near the mouth of Lenfesty's brook we find in the shore wall an exposure about 25 feet in hight, at the base of which are red shales overlain by red and white sandstones and conglomerates, then red shales followed by conglomerates and above these are gray hydraulic limestones. The conglomerates are variable in lateral extent, passing into sandstones but reappearing in great force to the south, the limestones disappearing. The pebbles of the conglomerate are at this horizon, largely of jasper and with a very small percentage of limestone of the character of the higher beds. On Bonaventure island the conglomerates also contain much jasper but the limestone pebbles predominate.

Mt Ste Anne. The sandstones and limestones of the lower beds are also seen in climbing Mt Ste Anne and in the vicinity of Irish-

town. All the higher beds of Mt Ste Anne are composed of limestone conglomerates with very little jasper and as the cement is calcareous it falls away freely. It was noted by Ells that these pebbles and boulders of the conglomerate contain Siluric fossils. We have found in them Chonetes canadensis, Spirifer murchisoni, Megalanteris plicata, Meristella arcuata and Dalmanites perceensis, all fossils of the

Limestone conglomerate, Mt Ste Anne

Percé rock; also Halysites catenularia, Heliolites, and in some sandstone pebbles a small Spirifer like S. vanuxemi. These fossil-bearing pebbles were found to the summit of the mountain even in the platform on which rests the shrine of Ste Anne. As this point is nearly 1400 feet above tide, the thickness of these red beds can not be less than 1200 feet and down along the shore land it seems to fill or to have stained all the depressions between the scarps of vertical limestone so that even on the shore when the soil is opened, blocks of the conglomerate are set free.

General remarks on the conglomerates

One is struck with the absence in the Percé region of the great thickness of the rusty brown Gaspé sandstones which at Little Gaspé rest conformably on the limestones and at Gaspé Basin carry marine fossils. Doubtless we are to find the contemporary of these deposits in the red and white sandstones of Percé, but they are only feebly developed and to them as an equivalent of the work elsewhere done, we must add some part of the conglomerate series. We follow ideas before expressed in regard to the tremendous deposits of the Gaspé sandstone, as sediments laid down first along an embayed coast and eventually in a deep coastal estuary which received heavy drainage from an elevated and rapidly decaying land surface. That estuary may have extended far to the southeast and at times it appears to have been shut off from the ocean entirely by the upbuilding of bars across its mouth but it was virtually and for long periods a coastal lagoon subject to inroads from without in times of stress.

Then was the period of Old Red lakes in New York, in Scotland, Orkney and Russia. They did not all begin at the same period of time nor continue their existence for equal times; some began in the late Siluric, others in middle Devonic, several are known to have continued their existence beyond the Devonic and into the Carbonic. So here, we are disposed to believe, this peculiar mode of sedimentation has transcended the limits of Devonic time and entered the Carbonic, though we have no traces of marine life of either period after the deposition was once established. The conglomerates of eastern Gaspé are contrasted with the sandstones of the more westerly parts of the county, and we may interpret them as the deposits of the seaward ends of the long estuary where for countless time the waters of the sea beat, as today, on the upturned edges of the ancient limestone cliffs and rolled their fragments up along the margin of an ever sinking continent.

Conclusion

From the future detailed study of the faunas preserved in this series of Siluric and Devonic limestones, we may expect a flood of light on the significance of contemporaneous faunas in the northern

Appalachian basin. In the Percé rock and its more northerly development in the limestones of Grande Grève, we confidently look for a solution of the questions of origin and derivation of the faunas which represent the earliest Devonic life of the Appalachian basin, and their path of migration once determined, evidence to infer the outline of the continental borders and the definition of the waterways.

In this brief sketch we have omitted from consideration through lack of personal acquaintance, reference to the Siluric limestones which occur in detached masses along the Malbay to the north, and at spots remote from Percé, along the southern coast. When these have been studied in detail, the entire series will be found to present an important supplement to our present knowledge of the factors of that ancient time.

UPPER SILURIC AND LOWER DEVONIC FAUNAS OF TRILOBITE MOUNTAIN, ORANGE COUNTY, NEW YORK

BY HERVEY WOODBURN SHIMER

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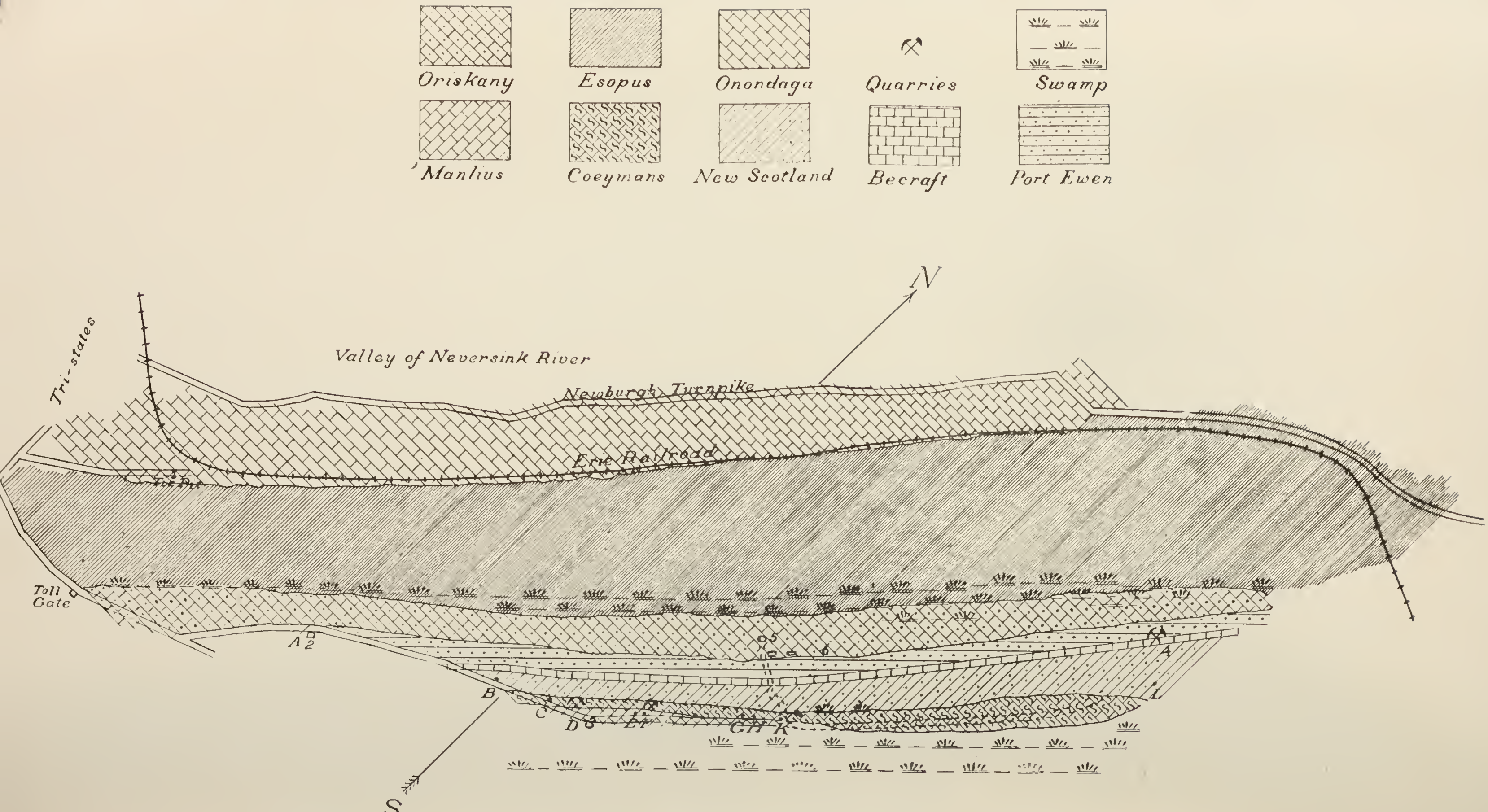

Geologic map of Trilobite Mountain

Scale. 1 mile = 6 inches

INTRODUCTION

Trilobite mountain, which is situated 3 miles southeast of Port Jervis, Orange co. N. Y., is a ridge with a maximum hight of about 750 feet, trending in a northeast-southwest direction. The ridge is about 2 miles long by 1 mile wide and is bounded on the northwest by the Neversink river and on the southeast by the marsh separating this ridge from Shawangunk mountain, which like all other of the Blue Ridge ranges trends from the northeast to the southwest.

Both the valley of the Neversink and that containing the marsh between the Shawangunk and Trilobite mountains are simple mon-

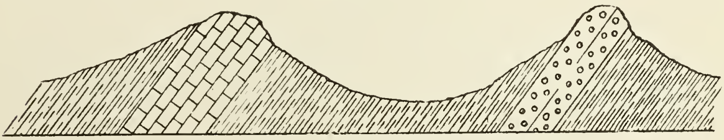

Fig. 1 Simple monoclinal valley (Rogers)

oclinal valleys [fig. 1][1]. The Onondaga and Marcellus formations underlie the former, the upper Medina to Manlius the latter valley.

Trilobite mountain, as noted by Dr Barrett[2], constitutes one of a series of anticlines extending in a northeast-southwest direction. In other words, this monocline is crossed by a " secondary system of flexures which cause the Helderberg Ridge to rise and sink in a succession of anticlinal and synclinal folds . . . The roads are in the synclinals and the limestone quarries are in the southeast fronts of the anticlinals . . . Bennett's quarry is in one of these; Nearpass's and Buckley's quarries lie south and north of it respectively." To the central one of these ridges Mather and Horton gave (about 1840) the name Trilobite mountain, from the great abundance of trilobites found here in the rocks of the Lower Oriskany.[3]

The first paper published in reference to the geology of this region was by Dr William Horton on the geology of Orange county. Dr Horton, who was a resident of Craigville, Orange co. and a well

[1] Rogers, H. D. Geol. of Pa. 1858. v. 2, pt 2, p. 921.

[2] Am. Jour. Sci. Ser. 3. 1877. 13:385.

[3] Mather. Geol. N. Y. 1st dist. p. 333.

known local geologist, was made one of the assistant geologists of the first geological district of this State.[1] Dr Horton encountered the same difficulty in determining the dip of the Trilobite mountain beds that all later observers have had, namely a tendency to confound cleavage and bedding. He says that the Trilobite mountain strata " repose unconformably upon the Millstone grit (Shawangunk grit) at the western base of Shawangunk mountain."[2] On the next page, however, he hesitates and says that this southeast dip is " far from certain. The stratification is to me still uncertain."

Several years later, W. W. Mather, geologist in charge of the first district, published his report where we find that he reached more definite conclusions. Speaking of the Manlius and Helderbergian series, he says " These limestones dip in a west to northwest direction, lying upon the subjacent Shawangunk rocks conformably; but some of the strata are rather enigmatical and appear to dip to the east-southeast in consequence of the cleavage or shivering of the strata since their deposition. In some of the strata the real dip is evident, but in others it is not, and it was only after minute examination that the real direction was with certainty determined."[3]

Dr S. T. Barrett of Port Jervis gave in 1876[4] the result of many years detailed work on the rocks of this region. He correlated the strata with those farther north and west in New York State, giving the horizons and thicknesses from bottom to top as follows:

	Feet
1 Tentaculite limestone	20
2 Favosites limestone	2–5
3 Lower Pentamerus and Cherty	40
4 Delthyris shale	120
5 Upper quarry	10
6 Upper shale	150
7 Trilobite layers	5–10
8 Oriskany and Cauda Galli	500–800

[1] N. Y. Geol. Rep't 1st dist. 1839. p. 135.

[2] N. Y. Geol. Rep't 1st dist. 1839. p. 150.

[3] Geol. N. Y. 1st dist. 1842. p. 332.

[4] N. Y. Lyc. Nat. Hist. 11:290.

Heinrich Ries in his report on the geology of Orange county, N. Y.,[1] gives a concise description of the successive horizons with a few fossils from each. He notes the greater prominence of the cleavage in the higher beds, so that the "bedding is often totally obliterated."[2]

Besides the above, Beecher, Darton and Schuchert have done more or less work in reference to this region.

This mountain[3] which represents one limb of an anticline, is a typical monoclinal ridge of the Appalachian type. It is, however, not a simple ridge but is made up of many minor ridges, as the

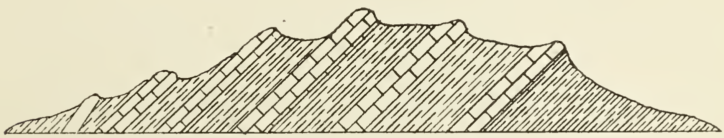

Fig. 2 Complex monoclinal ridge (Rogers)

accompanying ideal figure will show [fig.2].[4] All those dipping in the same direction contribute to the making of the mountain. We have here, then, what Rogers called a complex monoclinal ridge.[4]

These minor ridges, locally termed hogbacks, are usually, if not always, capped by a harder or more resistant stratum than that immediately beneath and are the result of normal erosion. Attacked by atmospheric agencies and in certain instances at least aided during present and past times by running water, the weaker stratum is disintegrated and washed away. The upper resistant stratum, thus undermined, breaks off by its own weight and falling, lies as talus covering the southeast slope of the hogback. The angle of slope of this talus depends on the size of the fragments. The northwest slope conforms in a greater or less degree to the dip of the beds.

There is evidence, in a slight development of slickensides etc., of more or less disturbance in the region, which leads one to suspect the presence of faults. The great development of hogbacks, which

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[1] N. Y. State Geol. 15th An. Rep't 1895. p.395-475.

[2] ——— p. 429.

[3] In altitude it is only a hill as the highest elevation is only about 750 feet.

[4] Rogers, H. D. Geol. of Pa. 1858. v. 2, pt 2, p. 920.

Fig. 3 Generalized section across Trilobite mountain

occur in all horizons but are specially characteristic of the Esopus, lends color to this supposition. These hogbacks, however, appear to be better explained as the result of differential erosion, as noted above. The more or less sudden rise and dying away of such a ridge in its northeast-southwest trend is apparently due to the greater or less development of certain cleavages; that is, where one of the characteristic cleavages at an angle to the bedding plane is well developed, erosion can most advantageously attack it.

The present paper gives a report on the succession of faunas in the strata of Trilobite mountain, from the Manlius to the Onondaga formation inclusive. Most of the field work was done during the summer of 1902, while the work on the collections was carried on during the summer and fall of 1903 in the laboratory of Columbia University. In the field work, great care was taken to distinguish between beds of varying lithic or faunal characters, by keeping separate the fossils collected from each, even though such differences were noted in a bed of less than an inch thick.

The accompanying map and sections were measured by pacing, and are subject to correction but in the acquisition of the fossils great precaution was taken against mixing the collections from higher or lower beds.

GENERALIZED SECTION AT TRILOBITE MOUNTAIN[1]

	Feet	Feet
Onondaga limestone (max. exposure)	235±	
Esopus grit	550±	
Oriskany limestone	180±	
Upper or Spirifer muchisoni zone		150±
Lower or Dalmanites dentatus zone		30±
Port Ewen beds	200±	
Becraft limestone	16	
New Scotland beds	170±	
Upper or Spirifer cyclopterus zone		125±
Lower		45±
Coeymans limestone	42	
Upper or Cherty		11
Middle or Chert free		28
Lower or Favosites bed		3
Manlius limestone (max. exposure)	41	

GENERAL DESCRIPTION OF HORIZONS

Manlius limestone

The Manlius limestone is exposed in six of the sections. It is a very compact, dark blue or almost black rock, containing many black shale seams. All the beds give evidence of more or less disturbance, the thin shale layers being at times minutely and irregularly crumpled, while the thicker beds, incapable of this minute displacement, present rather the appearance of little hillocks. Many calcite veins penetrate the rock mass, specially separating shale seams from the limestone. Chert occurs as scattered nodules but is not nearly as abundant as in the higher formations; it seldom gives any evidence of the presence of fossils, and even when deeply weathered it shows little else than a few crinoid joints.

The greatest thickness, 41 feet, is exposed in section F. The other sections give exposures varying in thickness from 2 to 31 feet.

Fossils are comparatively rare except in very restricted beds. The most characteristic and abundant species are Spirifer vanux-

[1] *See* fig. 3.

emi, Stropheodonta varistriata, Tentaculites gyracanthus and Whitfieldella? nùcleolata; the latter species is, however, confined to the upper 24 feet. Principally because of the restriction of this fossil to the upper beds, the Manlius has been separated into an upper and lower portion. The lower Manlius is exposed in the lower portions of sections E and F; it contains no fossils that are not likewise found in the upper Manlius. The upper Manlius is characterized by the first appearance of such Helderbergian species as Favosites helderbergiae and F. sphaericus.

Favosites bed[1] (Lower Coeymans, transitional)

The lithic character of the lower portion of this bed is similar to that of the Manlius, being a compact, dark blue limestone. The upper portion, however, is more coarsely crystalline through the presence of many crinoid joints, being a typical calcarenite.[2] The lower surface of the Favosites bed is, in places, very wavy and uneven, as though deposited upon an old, water-worn surface. The bed is composed almost entirely of heads of Stromatopora and Favosites. Where weathered, it is specially recognizable by the concentrically wrinkled laminae of the hydrozoon. At times these heads seem to have been deposited upon a yielding sediment which in places appears to be a continuation upwards of the Manlius and extends between and even partially covers these heads.

The fossils are most abundant by far in the lower third of this 3 foot bed. The most characteristic are Stromatopora concentrica?, Favosites helderbergiae, F. sphaericus and Zaphrentis roemeri. There are also found such characteristic Manlius forms as Whitfieldella? nucleolata, ostracods (probably Beyrichia) and Stropheodonta varistriata; the last, however, occurs also in the Coeymans proper. With these occur such Helderbergian forms as Lichenalia torta and Rensselaeria cf. aequiradiata. No Gypidula galeata occurs in the Favosites bed but immediately above it is exceedingly abundant.

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[1] This name was proposed by Barrett, N. Y. Lyc. Nat. Hist. v. 11.

[2] Grabau. Geol. Soc. Am. Bul. 14:349.

HELDERBERGIAN SPECIES

Favosites helderbergiae	Zaphrentis roemeri
F. sphaericus	Rensselaeria cf. aequiradiata

MANLIUS SPECIES

Whitfieldella ? nucleolata	Stropheodonta varistriata
Beyrichia ?	

Notwithstanding the absence of Gypidula galeata I have no hesitancy from the above fauna in placing the Favosites bed in the Coeymans limestone group. For detailed discussion of this bed see C 2, F 2 and H 2.

Coeymans (proper) middle and upper

The Coeymans (proper) is a heavy bedded, dark gray limestone, about 40 feet thick. It is usually very coarsely crystalline, being a typical calcarenite. The lower portion is chert free but in the upper part occur thin chert bands, ⅛ of an inch to 1 inch thick. It is characterized throughout its whole thickness by an abundance of specimens of Gypidula galeata.

The chert free beds contain in abundance Uncinulus nucleolatus, U. pyramidatus, Rhynchospira formosa, Spirifer cyclopterus, Atrypa reticularis, Favosites helderbergiae and F. sphaericus, while in the chert-bearing beds we meet such typical New Scotland forms occurring very abundantly as Meristella laevis, Streptelasma strictum, Leptaena rhomboidalis, Dalmanella subcarinata and Delthyris perlamellosa. Some of the chert bands contain very many bryozoa; specially abundant are Orthopora rhombifera, O. regularis, Unitrypa praecursa and Lioclema cellulosum. Lichenalia torta is found abundantly in both the upper and lower parts of the Coeymans. The Coeymans or pre-New Scotland species found here are Rhynchonella semiplicata ?, Stropheodonta varistriata and Gypidula galeata. Thus it is seen that the chert-bearing beds form a transition from the Coeymans to the New Scotland. But principally on the ground that no specimen

of the characteristic and abundant New Scotland fossil, Spirifer macropleura, was found in these chert-bearing beds and that Gypidula galeata continues very abundant, it was thought better to place this in the Coeymans than in the New Scotland division.

For detailed discussion of this horizon, see sections C, D and F.

New Scotland beds

The New Scotland beds represent an alternation of dense, dark blue, compact limestone with dark gray shales and thin-bedded sandstones. The limestone is at times very full of chert bands which in places make up almost half of the rock mass. These chert bands, like many of those in the upper Coeymans are, when weathered, one mass of fossils. This is a specially good place for the collection of the more delicate organisms. The arenaceous limestone beds at times exhibit a succession of light and dark laminae of paperlike thickness, as at K 15, L 2, and L 3. These thin beds contain either very few or no fossils except in the very lowest band. An exceedingly rapid change from a comparatively clear to a very black muddy water condition appears to have made it impossible for life to exist. Changes of current are also indicated by the appearance of pockets of coarsely grained limestone in the finely grained at L 3.

This formation is divided into an upper and a lower horizon. The division is based primarily on the great abundance of Spirifer cyclopterus in the upper 125 feet; this is exceedingly rare in the lower 45 feet. Spirifer macropleura is the diagnostic fossil of the New Scotland and is abundant throughout its whole extent. To the lower New Scotland are apparently confined such forms as Favosites sphaericus and many bryozoa, e. g. Orthopora rhombifera, O. regularis and Monotrypella? abrupta. Fragments of Lingula and Orbiculoidea occur frequently in calcareous, phosphatic, clay nodules; no manganese could be detected in these nodules.[1]

[1] In the upper New Scotland of western Maryland, Schuchert notes the occurrence of manganese-phosphatic nodules similar to those dredged from the present deep seas, but he does not think these indicate a deep water condition here, for the "stratigraphic evidence denotes a shallow sea before and after New Scotland times." U. S. Nat. Mus. Proc. 26:420.

Streptelasma strictum is also apparently more abundant in the lower than in the upper division. The upper beds are characterized by the great abundance of Coelospira concava. Common also in the upper beds are Atrypina imbricata, Stropheodonta becki, Trematospira multistriata and Cyrtolites expansus. Such forms as Stropheodonta becki and Strophonella headleyana are found much more frequently in shale than in limestone. This is also true of Spirifer macropleura but does not hold apparently for such species as Delthyris perlamellosa and Coelospira concava which are found with equal frequency in shale and in limestone.

Becraft limestone

This is a very dark gray, heavy bedded limestone. The lower portion is coarsely crystalline, a coarse calcarenite. Most of the formation, however, is finely crystalline, even at times rather shaly. A thickness of 16 feet is included in this formation. The lower 2½ feet are characterized by a great abundance of Gypidula pseudogaleata, the typical Becraft fossil. In this bed are also numerous specimens of Edriocrinus pociliformis and Leptaena rhomboidalis. The great abundance of the latter and several other New Scotland species in the Becraft of northern New Jersey is considered by Weller to be the chief difference which distinguishes its fauna from that of the preceding and succeeding beds.[1] Gypidula pseudogaleata was not found in the rest of the formation but owing to the great abundance of Spirifer concinnus which in great numbers usually characterizes the Becraft, and also of Leptaena rhomboidalis and Atrypa reticularis, these 14 feet are included. Spirifer concinnus is at times so abundant in these upper beds as to practically make up the entire rock mass. The other fossils also are those which are specially noticeable in the Gypidula pseudogaleata beds; yet the entire Becraft here represents a temporary invasion of a few typical Becraft species into the very slightly changing New Scotland seas, so that the mass

[1] Weller. Sur. N. J. 3:93.

of the New Scotland fauna continues through the Becraft into the Port Ewen. Only a few forms, such as Spirifer macropleura, unable apparently to live in the slightly purer waters, disappeared.

Port Ewen beds

The 200 feet included in this formation are mostly concealed. The few exposures are lithologically very similar to the New Scotland, varying from a dark blue limestone to a silicious shale. The fossils are likewise very similar to those of the New Scotland, including such typical forms as Stropheodonta becki, Strophonella punctulifera, Streptelasma strictum, Lichenalia torta and an abundance of Coelospira concava and Eatonia singularis. But the transitional character of the Port Ewen to the Oriskany is indicated by the presence of Meristella lata and Spirifer murchisoni. With the exception of these two fossils, all the species found in these beds are Helderbergian.

From the close of the Becraft to the uppermost Dalmanites dentatus beds the fauna is transitional from the typical Helderbergian to the Oriskanian. The fauna acquires more and more an Oriskanian aspect as the beds are ascended. Yet the lower beds contain so many very typical Helderbergian species that there is no hesitancy in placing these beds in the lower Helderberg. From the upper 30 feet of these transition beds, however, the above mentioned Helderbergian species are absent and there is a great increase of the Oriskanian element. It was thought well, therefore, on account of the very decided faunal change, to place these upper (D. dentatus) beds in the Oriskany.[1] The evidence for this is taken up in detail under the lower Oriskany.

Oriskany

The Oriskany is mainly a silicious limestone with the silicious content increasing perceptibly from the base upward. At times it is

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[1] Barrett likewise noted the close relationship of the fauna of the Trilobite bed to that in the rocks above: "The relations of the Dalmanites dentatus layer seem to be more with the rocks above than those below it." Am. Jour. Sci. ser. 3. 45:72.

quite heavily bedded; in other places it becomes very shaly; this latter condition is specially noticeable near the middle of the formation. It is divided into an upper (150 feet) and a lower (30 feet) division on faunal grounds entirely.

Lower Oriskany (Dalmanites dentatus zone)

FAUNA OF THE LOWER ORISKANY

Vermipora serpuloides *Hall* (H) c[1]
Beachia suessana *Hall* (O) R-c
Chonostrophia jervisensis *Schuch.* r-C[2]
Cyrtina rostrata *Hall* (O and On) r
Dalmanella subcarinata *Hall* (H) R-C
Leptaena rhomboidalis (*Wilck.*) (Trenton-Waverly) R-c
Leptostrophia oriskania *Clarke* (O) R
Meristella lata *Hall* (O) r
Nucleospira elegans *Hall* (Niagara-H) c
Orbiculoidea ampla *Hall* (O) r
Orthothetes woolworthanus *Hall* (H) c
Rensselaeria aequiradiata (*Con.*) (H) R
R. subglobosa *Weller* c-C
Rhipidomella oblata *Hall* (H) r
Spirifer murchisoni *Castel.* (O) r-c
Stenochisma formosa *Hall* (H) r
Strophonella? conradi *Hall* (H) r
Uncinulus vellicatus *Hall* (H) R
Actinopteria textilis (*Hall*) (H) R-C
A. textilis arenaria (*Hall*) (O) R
Diaphorostoma nearpassi (*Weller*) R
D. ventricosum (*Con.*) (H and O) R
Loxonema jerseyense *Weller* ?-c
Platyceras platystoma *Hall* (H) r
P. ventricosum *Con.* (H and O) R
Tentaculites acula *Hall* (H) r-c
T. elongatus *Hall* (H and O) r
Dalmanites dentatus *Barr.* R-C
D. dolphi *Clarke* R[3]
Homalonotus vanuxemi *Hall* (H) c

Out of the above fauna of 30 species, 6 have so far been found only in these beds, 4 occur in both Helderbergian and Oriskanian, 13 are Helderbergian and 7 are Oriskanian species. Omitting from the consideration all that are very rare (R), there are present 11 Helderbergian and 5 Oriskanian species, which vary in number

[1] R=very rare; r=rare; c=common; C=very common. H=Helderbergian; O=Oriskanian; On=Onondagan species. ?=species doubtful. When no horizon is given, the species has been found in the beds of this region only (i. e. northwestern New Jersey and southern New York).

[2] Schuchert notes the occurrence of the species in the Becraft of the Port Jervis region. Am. Geol. 27:250.

[3] Described from these beds but not seen by me.

from rare (r) to very common (C). The Helderbergian species outnumber the Oriskanian two to one; but this predominant Helderbergian aspect disappears when the individual species are examined. The Helderbergian species, Vermipora serpuloides, Dalmanella subcarinata, Rhipidomella oblata, Nucleospira elegans and Stenochisma formosa are also found in the calcareous Oriskany of other regions associated with the large normal Oriskany shells.[1] Tentaculites elongatus is much more characteristic of the uppermost calcareous Oriskany than of the lower Helderberg, but it is specially the very typical Oriskany species, Beachia suessana, Meristella lata and Spirifer murchisoni which give the distinct Oriskanian aspect to these beds; these are abundant and normal in their development, and occur from the base to the top of these beds. Besides these, Rensselaeria subglobosa, Dalmanites dentatus and D. dolphi, though at present hardly known outside the beds of this region, are more Oriskanian in appearance than Helderbergian.

The development of marginal crenulations and spines on the cephalon and pygidium is characteristic of many Devonic trilobites.[2] In the genus Dalmanites this is scarcely noticeable in the Helderbergian but becomes exceedingly conspicuous in the Oriskany, Schoharie and Onondaga. It is first noticed as slight crenulations on the anterior portion of the cephalic margin of the species pleuroptyx Green of the Lower Helderberg; in stemmatus Clarke of the calcareous Oriskany this crenulation is extended back along the margin of the cephalon; while in dentatus Barrett it is greatly accentuated into denticulations. This reaches its maximum development in the regalis Hall of the Schoharie and Onondaga. The appearance of such a highly ornamented Dalmanites as dentatus Barrett would on *a priori* grounds be placed *above* the Helderbergian. All the above named species considered as a whole are so characteristically Oriskanian that it is believed

[1] van Ingen & Clark, P. E. N. Y. State Paleontol. An. Rep't. 1902. p.1203-4; and Clarke N. Y. State Mus. Mem. 3, p.65-67.

[2] *See also* Clarke. N. Y. State Mus. Mem. 3, p. 87.

they far outweigh the greater number of Helderbergian species. It is on this account that these beds have been included in the Oriskany.

With the inclusion of these beds in the Oriskany the question of correlation with the Oriskany of other regions at once arises. Are these lower as well as the upper beds the time equivalent of the arenaceous Oriskany as developed at Oriskany Falls, New York, or do they represent in time a part of the unconformity beneath the normal Oriskany and would, therefore, be an older or lower Oriskany?

Large Rensselaerias are characteristic of the typical Oriskany. Beachia suessana is a small and earlier form of this same type; it is one of the most abundant shells of these beds and is practically absent from the upper beds and from the Helderbergian below. Rensselaeria subglobosa is another small and very abundant non-Helderbergian species confined to these lower beds. The following species occurring here are quite typical of the lower Helderberberg: Rensselaeria aequiradiata, Nucleospira elegans, Stenochisma formosa, Uncinulus vellicatus, Actinopteria textilis and Homalonotus vanuxemi. None of the following normal Oriskany species were found here: Rensselaeria ovoides, Megalanteris ovalis, Camarotoechia barrandei, Leptocoelia flabellites, Spirifer arenosus, Chonostrophia complanata and Hipparionyx proximus.

With the presence of the forms noticed above which foreshadow the normal Oriskanian fauna, the presence of a very decided Helderbergian element and the absence of so many typical Oriskanian species, an earlier fauna than the normal Oriskanian appears to be indicated. They have, therefore, been called Lower Oriskany.[1]

[1] Of the 30 species cited by Schuchert from the Camden (Tenn.) Lower Oriskany, 22 species are typical Oriskanian or later, 6 are Helderbergian, Eatonia peculiaris occurs in both and Atrypa reticularis ranges through the Siluric and Devonic; Hipparionyx proximus and Rensselaeria ovoides are questionably present. The typical Helderbergian Meristella laevis and Pterinea? cf. textilis

The Trilobite bed for which the Lower Oriskany here is specially noted is a dense, dark blue limestone containing many trilobite fragments, specially of Dalmanites dentatus and Homalonotus vanuxemi. The former species is specially abundant, whence the name "dentatus fauna" for the Lower Oriskany. It likewise contains a great abundance of Rensselaeria subglobosa, Chonostrophia jervisensis, Actinopteria textilis and Loxonema jerseyense. It is bounded above and below by an inch of silicious limestone. This bed maintains a uniform thickness of from 4 to 6 inches.

Upper Oriskany (Spirifer murchisoni zone)

The upper Oriskany is characterized by dark blue silicious limestone and shale, and has an approximate thickness of 150 feet. Chert bands occur more or less frequently throughout the entire formation, but specially in the upper portion. At times these show no traces of any fossils even when weathered; at other times they are one mass of fossils. Unlike the chert bands of the upper Coeymans and Lower New Scotland, these fossiliferous bands apparently contain no bryozoa.

This formation is specially characterized by Spirifer murchisoni, Meristella lata, Leptocoelia flabellites, Coelospira dichotoma, Actinopteria textilis arenaria, Diaphorostoma ventricosum and Tentaculites elongatus. The lower portion contains an abundance of Orbiculoidea jervisensis. This large brachiopod is very noticeable, even at quite a distance from the exposure, as it occurs frequently at right angles to the bedding. The most characteristic fossil is Spirifer murchisoni, and hence the name "murchisoni zone."

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are present. Omitting from the above all species marked questionable, there remain 15 characteristic of the Oriskany or later (Onondaga) and 5 of the Helderbergian. [Safford, J. M. & Schuchert, Charles. The Camden (Tenn.) Lower Oriskany. Am. Jour. Sci. ser. 4? 7:429-32]

This Camden Oriskany is developed at least as far north as western Maryland where, according to Schuchert, the lower portion of the Oriskany "recalls the Oriskany of Camden, Tennessee, and points to an older stage than the Oriskany as usually known." [Schuchert. On the Lower Devonic and Ontaric Formations of Maryland. U. S. Nat. Mus. Proc. 26:420]

FAUNA OF THE UPPER ORISKANY

Coelospira dichotoma *Hall* (O) r-c
Leptocoelia flabellites (*Con.*) (O and On) r-c
Beachia suessana *Hall* (O) R
Chonostrophia complanata *Hall* (O) r
Dalmanella subcarinata *Hall* (H) r
Megalanteris ovalis *Hall* (O) ?
Meristella lata *Hall* (O) r-C
Orthothetes woolworthanus *Hall* (H) C
Reticularia modesta (*Hall*) (H) r
Spirifer arenosus (*Con.*) (O and On) ?
S. cyclopterus *Hall* (H and O) R
S. murchisoni *Castel.* (O) r-C
Stropheodonta becki *Hall* (H) r
Actinopteria textilis arenaria (*Hall*) (O) c
Pterinea? gebhardi (*Con.*) (O) r
Diaphorostoma desmatum *Clarke* (O) r
D. ventricosum (*Con.*) (H and O) r-C
Platyceras lamellosum *Hall* (H) R
P. reflexum *Hall* (O) ?
Conularia pyramidalis jervisensis *Shimer* r
Tentaculites elongatus *Hall* (H) r-C

Out of a fauna of 21 species, one was found in the beds of this region only, two are equally characteristic of the Helderbergian and Oriskanian, six are Helderbergian and 12 Oriskanian. Omitting from consideration all questionable and very rare species, there remain 5 Helderbergian and 8 Oriskanian species.

From the abundance of such typical Oriskany species as Leptocoelia flabellites, Coelospira dichotoma, Chonostrophia complanata, Meristella lata, Spirifer murchisoni and Actinopteria textilis arenaria there is no doubt that these beds should be placed in the Oriskany. Although the Helderbergian forms occurring here are not very typically such, yet they indicate a persistence of Helderbergian species in this region to the beginning of the Esopus, for in the uppermost Oriskany beds occur such Helderbergian forms as Stropheodonta becki, Reticularia modesta and Tentaculites elongatus side by side with Spirifer murchisoni, Meristella lata and Leptocoelia flabellites. Yet the larger and specially characteristic fossils of the typical Oriskany as developed at Oriskany Falls, are mostly wanting in these beds. Rensselaeria ovoides, Hipparionyx proximus and Camarotoechia bar-

randei were not found, while Megalanteris ovalis and Spirifer arenosus were questionably identified from a few fragments. In northwestern New Jersey Weller[1] notes the presence of Hipparionyx proximus but it is exceedingly rare and abnormal in its small size; Spirifer arenosus is one of the rarest shells of the New Jersey Oriskany of that region, while Camarotoechia barrandei is questionably present.

Instead of deriving an argument in favor of Helderberg-Oriskany transition beds from the practical nonoccurrence of the very typical larger shells of the normal Oriskany, and from the commingling of Helderbergian and Oriskanian species, it is believed with Clarke[2] that these beds which are stratigraphically the equivalent of the Oriskany, represent the calcareous (deep water) facies of the shallow water original Oriskany. Just as at present much of the older life, geologically considered, is found in the deeper portions of the sea,[3] so here the Helderbergian types persisted in the deeper water; not being able, evidently, to compete with the newer Oriskany fauna, they found safety in the less favorable localities, just as the Insectivores among mammals have persisted to the present, notwithstanding their low development, because, added to a maintenance of small size, they have become nocturnal in habit and in many ways have adapted themselves to the less desirable localities.

Large size is usually correlated with an abundance of food. In the sea the more abundant food supply is in comparatively shallow waters. It is here that marine vegetation flourishes, on which all sea animals primarily depend for food; it is here also that riverborne detritus, which contains a greater or less amount of food, is

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[1] Geol. Sur. N. J. 1902. 3:341–64.

[2] Oriskany Fauna of Becraft Mountain. N. Y. State Mus. Mem. 3, p. 72.

[3] Alexander Agassiz discusses this point quite thoroughly in his work, the *Three Cruises of the U. S. Coast and Geodetic Survey Steamer Blake,* v. 1, from which the following conclusions are quoted:

"The abyssal fauna has descended from the littoral and other shallow regions, to be acclimatized at great depths." [p. 155]

"All the evidence thus far tends to show that the deep sea fauna originated at the close of the Paleozoic times." [p.151]

After noting that a large number of antique types occur everywhere, he continues, "We can only say that in the deep water fauna a relatively larger number of such antique forms have been found than elsewhere." [p.156]

Plate 1

Oriskany-Esopus swamp, looking southwest; from near the residence of William Balmos

Plate 2

Oriskany-Esopus swamp, looking southwest. The Oriskany ridge is at the right of the picture; the Oriskany-Esopus swamp at the left.

mostly deposited. It would, therefore, be expected that the larger shells would not be found in the very deep waters i. e. below the depths at which marine algae flourish. This theory is supported by the work of Agassiz while associated with the dredging steamer Blake.[1] In discussing Gastropods and Pelecypods, he thus concludes, "Deep sea dredging has thus afforded few specimens of even moderately large size, judged by the standard of shallow water or littoral shells."

It thus seems well to look on the fauna of these upper Oriskany beds as existing in deeper portions of the sea at the same time that the typical Oriskany Falls fauna lived in comparatively shallow waters. Yet this deeper portion was not removed beyond the reach of land-derived sediment for the beds are more or less argillaceous and silicious limestones.

All the large fossils of the original Oriskany noted above as practically absent from the Port Jervis region, are very abundant at Becraft mountain[2] and also, with the exception of Camarotoechia barrandei, near Rondout N. Y.[3] But they are likewise associated in these regions with many Helderbergian forms. The practical absence of these fossils from the Port Jervis region can not be due to insufficient time for the migration of the species into this region, as they occur both south in Maryland, with also many in Pennsylvania, as well as north in New York State. Nor can it be due to some barrier since many typical Oriskany forms occur here. It may possibly be due to a greater depth of water.

Oriskany-Esopus swamp

This swamp probably rests on the upper beds of the Oriskany, being worn out of the more easily disintegrated Esopus. The preglacial drainage having been obstructed, this has been filled in to a depth of probably 20 or 30 feet in places. It is interesting to note that on Becraft mountain, also, "the contact between the Oriskany

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[1] Agassiz, Alexander. Three Cruises of the U. S. Steamer Blake, 2:62.

[2] Clarke, J. M. Oriskany Fauna of Becraft Mountain. N. Y. State Mus. Mem. 3, p.67.

[3] van Ingen & Clark, P. E. Disturbed Fossiliferous Rocks in the Vicinity of Rondout, N. Y. N. Y. State Paleontol. An. Rep't. 1902. p. 1203.

and Esopus is everywhere marked by low, swampy ground and by the existence of stream beds."[1]

Esopus

The Esopus is a dark gray silicious shale. It has an approximate maximum thickness of 550 feet. The very strong cleavage which has been induced in it has given rise to very thin, platelike pieces. The entire Esopus is a continuous succession of hogbacks, giving an appearance very similar to a series of step faults. Yet this appearance may be due merely to differential weathering on account of the greater development of certain cleavages over others. This latter theory is partially borne out by the fact that the valleys between the hogbacks run parallel to the strike of the beds.

No fossils were found in the Esopus though prolonged search was made for them. Irregular pyrite nodules are very abundant in all parts of the Esopus and Lower Onondaga. For 50 or more feet up into the Onondaga, probably a fourth of the many fossils found are pyritized. This suggests that perhaps each of the Esopus nodules also represents what is left of one or more fossils after the wonderful cleavage to which it has been subjected.

The Schoharie grit is here included in the Esopus on account of the absence of fossils and the lithic similarity of the two formations.

Onondaga

The transition from the Esopus to the Onondaga is very gradual. The lowest, much cleaved beds are arenaceous shales and except for the fossils would be placed in the Esopus. The beds become more calcareous till 30 feet above the base, a typical calcareous shale is developed. Here the fossils are quite numerous though few in species. The most abundant species are Coelospira acutiplicata and C. grabaui. The strata continue principally as calcareous shales for over a hundred feet but with the occurrence of thin bands of limestone more and more frequently toward the top. For the next 40 or 50 feet the limestone and calcareous shale beds are about equal in number and thickness. Here

[1] Grabau, A. W. Stratigraphy of Becraft Mountain, Columbia County, N. Y. N. Y. State Paleontol. An. Rep't. 1902. p. 1069.

Plate 3

View from the Esopus ridge looking northeast across the Oriskany-Esopus swamp and Oriskany ridge to Shawangunk mountain. The low ridge at the right of the picture is Trilobite ridge.

the most abundant fossils are *Atrypa reticularis*, *Spirifer macrus*, *Reticularia fimbriata*, *Phacops rana* and *Chonetes hemisphericus*. Above this the rock becomes a heavy limestone with thin shale seams at intervals. There are thus over 200 feet of the Onondaga laid down before the formation becomes the typical heavy bedded limestone usually associated with this formation. In the uppermost portion chert bands make their appearance. This chert is so thoroughly mixed through the limestone that it has when weathered an exceedingly rough appearance. Two hundred and thirty-five feet of the Onondaga is estimated to be here exposed. White[1] gives a thickness of 250 feet for Port Jervis. For a detailed discussion see K 14 to K 23.

REFERENCES TO DETAILED DISCUSSION

Those underscored are represented by fossils

Lower Manlius—E 1a-f, F 1a-n

Upper Manlius—D 1, E 1g-m, F 1p, F 1q, G 1, H 1, K 1

Favosites bed—D 2, F 2, H 2, Lower K 2

Coeymans—C 1, C 2, C 3, D 3, D 4, D 5, D 6, D 7, F 3, F 4, F 5, F 6, F 7a-c, Middle K 2

Lower New Scotland—C 4, Lower C 5, D 8, Lower D 9, F 7d, Lower F 8, Upper K 2, K 3, K 4, K 5, K 6, K 7, K 8, K 9, K 10, K 11, Lower L 1.

Upper New Scotland—Lower B 1, Upper C 5, C 6, Upper D 9, D 10, Lower D 11, Upper F 8, F 9, Lower F 10, K 12, K 13, K 14, K 15, K 16, K 17, K 18, Upper L 1, L 2, L 3

Becraft—Middle B 1, Lower D 11, Lower F 10, Lower K 19, L 4, L 5, L 6

Port Ewen—Lower A 1, Upper B 1, Lower B 2, Upper D 11, D 12, D 13, Lower D 14, Middle F 10, Upper K 19, K 20, K 21, L 7, Lower L 8

[1] 2d Geol. Sur. of Pa. G6, p.119.

Lower Oriskany—Upper A 1, Lower A 2, Upper B 2, Upper D 14, Lower D 15, Upper F 10, F 11, K 22, K 23, K 24, K 25, K 26, K 27, K 28, Lower K 29, Upper L 8, L 9, Lower L 10

Lower Oriskany (Trilobite bed)—Top of B 2, Top of D 14, F 11, K 27

Upper Oriskany—Upper A 2, A 3, A 4, A 5, A 6, Upper D 15, F 12, Upper K 29, K 30, K 31, K 32, K 33, K 34, K 35, K 36, K 37, K 38, K 39, K 40, K 41, Upper L 10, L 11, L 12, L 13, Lower L 14

Esopus—K 41, Upper L 14, L 15

Onondaga—K 42, K 43, K 44, K 45, K 46, K 47, K 48, K 49, K 50, K 51

COMPARISON WITH SIMILAR HORIZONS IN OTHER REGIONS

Becraft mt e. N. Y.	Rondout e. N. Y.	Trilobite mt s. e. N. Y.	Nearpass quarries n. w. N. J.	W. Md. and n. e. W. Va.	
1	2	3	4	5	
300± ft	300–325	550±	375	Land cond.	Esopus
1–several	20–70	180±	170	348	Oriskany
25	110–200	200±	80	Not recog.	Port Ewen
40–45	40	16	20	85	Becraft
68	100±	170±	160	64	New Scotland
45	50	40	40	110	Coeymans
55	45	41±	35	110 (6)	Manlius
240	365–505	647	505	717	Manlius-Oriskany inclusive

A short description of each section follows.

1 Grabau. Stratigraphy of Becraft Mountain, Columbia Co., N. Y. N. Y. State Paleontol. An. Rep't 1902. p.1030-79.

2 van Ingen & Clark, P. E. Disturbed Fossiliferous Rocks in the Vicinity of Rondout N. Y. N. Y. State Paleontol. An. Rep't 1902. p.1176-1227.

3 The present paper.

4 Weller. Rep. on Pal. Geol. Sur. of N. J. 3: 56-102.

5 Schuchert. On the Lower Devonic and Ontario Formations of Maryland. U. S. Nat. Mus. Proc. 26: 413-24.

6 This includes all of the strata from the Salina to the Coeymans.

. 1 At Becraft mountain, Columbia county, N. Y., Grabau gives the following lithic and faunal characters for these formations.[1] In

[1] Stratigraphy of Becraft Mountain, Columbia County, N. Y. N. Y. State Paleontol. An. Rep't. 1902. p. 1030–79.

comparing 1, 2 and 3 it should be noted that the distance between Becraft and Rondout is not nearly so great as it is between Rondout and Port Jervis.

Manlius .... 55 feet

Three Stromatopora beds occur, 0, 2 and 12 feet respectively below the top of the Manlius. Besides the Stromatopora, the most characteristic fossils are Spirifer vanuxemi, S. corallinensis, S. eriensis var., Whitfieldella cf. nitida, etc.

Coeymans .... 45 feet

Layers of chert are not infrequent in this limestone, an argillaceous calcarenite.[1] The lowest bed of this, resting immediately on the uppermost Stromatopora bed, contains some specimens of Favosites helderbergiae and many of Gypidula galeata. In the Coeymans were also found Delthyris perlamellosa, Spirifer cyclopterus, S. macropleura (one specimen), Leptaena rhomboidalis, Pterinea? textilis (one specimen), etc.

New Scotland .... 68 feet

Thin bedded, argillaceous to silicious rocks with a variable amount of lime carbonate present. Orthothetes woolworthanus, Stropheodonta becki, Spirifer macropleura, Delthyris perlamellosa, Eatonia peculiaris, E. medialis, Diaphorostoma ventricosum, etc.

Becraft .... 40-45 feet

Coarsely crystalline limestone (calcarenite). The most abundant and characteristic species are Spirifer concinnus, Gypidula galeata (usually small), Atrypa reticularis and Uncinulus campbellanus.

Port Ewen.. 25 feet

A dark crystalline limestone, very similar to the Coeymans. Monotrypella tabulata specially characterizes this horizon; this is, however, also found in the Coeymans. Other fossils are Spirifer concinnus, S. cyclopterus, Del-

[1] Grabau. Science. Feb. 20, 1903. p. 297.

thyris perlamellosa, Rhynchospira formosa, Eatonia peculiaris, etc.

Oriskany .... 1-several feet

A silicious limestone. The following are a few of the fossils found here by Clarke,[1]—Chonetes hudsonicus, Tentaculites elongatus, Cyrtolites expansus, Diaphorostoma ventricosum, Eatonia medialis, Coelospira concava, Leptocoelia flabellites, Meristella lata, Spirifer murchisoni, Chonostrophia complanata, Edriocrinus becraftensis, etc.

Esopus and Schoharie............................ 300 ± feet

2 At Rondout east of Kingston, van Ingen and P. E. Clark have worked up the following section.[2] This is the northeast continuation of the same ridge in northern New Jersey and at Port Jervis. Its further continuation is seen in Becraft mountain.

Manlius .... 45 feet

The lower and upper divisions contain many specimens of Leperditia alta, Spirifer vanuxemi, and Stropheodonta varistriata. The middle part contains an abundance of Stromatopora, "a veritable coral reef."

Coeymans .... 50 feet

The basal bed of 5 feet contains many specimens of Gypidula galeata, Spirifer cyclopterus, S. concinnus, Lichenalia torta and Stropheodonta varistriata (both flat and highly convex varieties). The middle beds are cherty limestones with no Stropheodonta varistriata noted. The upper beds are shaly limestones with an abundance of Uncinulus nucleolatus, Atrypina imbricata, Bilobites varicus, etc. Gypidula galeata is abundant in all the beds.

New Scotland.................................. 100± feet

Shaly limestone alternating with thin bands of semicrystalline

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[1] N. Y. State Mus. Mem. 3, p.65-71.

[2] van Ingen, Gilbert & Clark, P. E. Disturbed Fossiliferous Rocks in the Vicinity of Rondout N. Y. N. Y. State Paleontol. An. Rep't. 1903. p.1176-1227.

limestone. The lower portion has considerable chert; it is characterized by an abundance of Orthothetes woolworthanus, Stropheodonta becki, Spirifer cyclopterus, S. macropleura, Delthyris perlamellosa, etc. The most abundant species in the middle beds are Orthothetes woolworthanus, Strophonella radiata, Delthyris perlamellosa; no other Spirifers are noted. The upper beds contain many specimens of Spirifer cyclopterus, S. concinnus, Uncinulus campbellanus and Aspidocrinus scutelliformis, and numerous specimens of Gypidula pseudogaleata. A few of Delthyris perlamellosa are here noted but none of Spirifer macropleura.

Becraft .... 40 feet

A coarsely crystalline limestone. The fauna of this is identical with that of the upper New Scotland with the exception of a relatively greater abundance of the species above noted and the nonoccurrence of Spirifer cyclopterus.

Port Ewen.................................. 110-200 feet

Silicio-argillaceous limestone. The lowermost beds gave the following abundant species: Leptaena rhomboidalis, Orthothetes woolworthanus, Dalmanella perelegans, Delthyris perlamellosa, Spirifer concinnus, Rhipidomella oblata, Meristella laevis, etc. In the upper beds were noted[1]: Pholidops ovata, Rhipidomella oblata, Stropheodonta becki, Coelospira concava, Spirifer modestus, Cypricardinia lamellosa, Tentaculites elongatus, Homalonotus vanuxemi, Phacops logani, Dalmanites pleuroptyx, etc.

Oriskany .... 30-70 feet

The lower portion is a pebble bed.................... 6-18 feet

The upper portion consists of alternating sandy and cherty limestones .... 20-50 feet

[1]Clarke. Oriskany Fauna of Becraft Mountain. N. Y. State Mus. Mem. 3. 1900. p.73.

North of Rondout at Glenerie, the entire Oriskany has a thickness of but 20 feet.

Here the Oriskany contains the following mixture of New Scotland and Oriskany species as noted by van Ingen. Common ones only will be noted.

New Scotland species
- Chaetetes sphaericus
- Dalmanella perelegans
- Eatonia medialis
- E. singularis
- Orthothetes woolworthanus
- Rhipidomella oblata
- Spirifer cyclopterus

Oriskany species
- Actinopteria arenaria
- Anoplotheca dichotoma
- Leptocoelia flabellites
- Beachia suessana
- Chonostrophia complanata
- Cyrtina rostrata
- Edriocrinus sacculus
- Hipparionyx proximus
- Meristella lata
- Spirifer arenosus
- S. modestus
- S. murchisoni
- Tentaculites elongatus

Esopus . . . . 300-325 feet

4 Nearpass quarry in northwestern New Jersey. Weller.

About 3 or 4 miles to the southwest in the continuation of Trilobite mountain, occurs an excellent exposure, specially of the lower beds, in the limestone quarry of William Nearpass. This section was studied by Stuart Weller[1] and the following measurements given.[2]

Manlius . . . . 35 feet

The most characteristic fossils are Spirifer vanuxemi (only in the upper portion), Stropheodonta varistriata, Leperditia alta and Tentaculites gyracanthus. Stromatoporoid masses are abundant in the lowest part.

Coeymans . . . . 40 ± feet

A more or less cherty limestone. In the basal portion is an abundance of Favosites helderbergiae and Stromatopora. The most characteristic fossils of this formation are Gypidula galeata, Spirifer cyclopterus, Uncinulus mutabilis, etc.

[1] 1902. Geol. Sur. N. J. Paleontology, 3:56-102.

[2] —— p. 58-60.

New Scotland .... 180 ± feet

The lowest part of 20 ± feet is a cherty limestone, containing no Spirifer macropleura but many specimens of Enterolasma strictum, Delthyris perlamellosa, Spirifer cyclopterus, etc.

The middle 140 ± feet are calcareous shales specially characterized by an abundance of Spirifer macropleura. Other fossils are Coelospira concava, Atrypina imbricata, Trematospira multistriata, etc.

The upper 20 ± feet are a hard, cherty limestone and correspond in stratigraphic position to the *Becraft*. They contain no Gypidula pseudogaleata or Spirifer concinnus. Leptaena rhomboidalis is specially abundant.

Port Ewen (estimated)........................ 80 ± feet

Not exposed.

Oriskany .... 170 ± feet

Silicious limestone.

The lower 30 ± feet, Dalmanites dentatus zone, is specially characterized by an abundance of Chonostrophia jervisensis, Rensselaeria subglobosa, Dalmanites dentatus, etc.

The next 20 ± feet, Orbiculoidea jervisensis zone, is very similar to the Oriskany of Becraft mountain.

The upper 120 ± feet, Spirifer murchisoni zone, contains an abundance of Spirifer murchisoni, Leptocoelia flabellites, Meristella lata, Diaphorostoma ventricosum, Tentaculites elongatus, etc.

Esopus .... 400 ± feet

5 In western Maryland at Cumberland, Keyser, etc., the following composite section has been given by Schuchert.[1]

Manlius .... 110 feet

In the lower part, Favosites helderbergiae praecedens, Rhynchonellas like Uncinulus campbellanus and also Nucleospira are abundant.

[1] On the Lower Devonic and Ontaric Formations of Maryland. U. S. Nat. Mus. Proc. 1903. 26:413–24.

In the middle occur in great numbers, Sphaerocystites multifasciatus, Spirifer modestus and Rhynchonella formosa.

In the upper portion, the most abundant species are, Tentaculites gyracanthus, Calymmene camerata, a small form of Gypidula near G. galeata, Orthopora, Lioclema, etc.

Coeymans .... 110 feet

In the lower part fossils are rare; Atrypa reticularis and Leptaena rhomboidalis occur.

The middle portion specially abounds in Stromatopora and at intervals Tentaculites gyracanthus. Layers of chert are more or less prominent.

The upper part contains typical Gypidula galeata and Spirifer cyclopterus.

New Scotland.. 64 feet

The lower two thirds is a cherty limestone and is characterized by Spirifer macropleura. There also occur here Edriocrinus pocilliformis, Eatonia medialis, E. singularis, Coelospira concava, Trematospira multistriata, Delthyris perlamellosa, Spirifer cyclopterus, Phacops logani, etc.

The upper one third consists of argillaceous shales with occasional manganese-phosphatic nodules. Spirifer macropleura, Orthothetes woolworthanus, Stropheodonta becki, etc. occur here.

Becraft .... 85 feet

"The fauna is most abundant in the upper half, where Rensselaeria aequiradiata is the most characteristic fossil. No Spirifer macropleura occurs here. Other fossils are a small Leptocoelia flabellites, Spirifer cyclopterus, S. concinnus, Cyrtina, etc."

Port Ewen. Not recognized as such in Maryland.

Oriskany .... 348 feet

The lower 90 feet, which are silicious shales, contain near the base Leptocoelia flabellites; just below the middle, Lep-

tocoelia flabellites, Spirifer tribulis, Beachia suessana immatura, Tentaculites acula, Diaphorostoma desmatum, etc. and, near the top, there are many specimens of Chonetes hudsonicus.

The upper 258 feet of calcareous sandstone contain in the lowest beds, Spirifer cumberlandiae, S. concinnoides, etc. but fossils are rare in the lower 100 feet; the upper 158 feet contain the typical Hipparionyx fauna.

Esopus, Schoharie and Onondaga are wanting in Maryland and farther south, the Marcellus being deposited on the eroded Oriskany.

Conclusions

From the above it is seen that the Manlius is faunally very similar in the New York and New Jersey sections but differs in the Maryland section in that the latter contains many such Coeymans fossils as the bryozoan Orthopora and brachiopods closely resembling Uncinulus campbellanus (Hall) and Gypidula galeata (Dalman). The latter also contains such Cobleskill species as Calymmene camerata Conrad.

The Coeymans of all the sections is similar in the development of chert in the middle beds. Sections 1, 3 and 4 agree in having a basal coral zone while 1, 2, 3 and 4 agree in having the upper beds shaly in character, with Gypidula galeata (Dalman) abundant in the whole of the formation. In Maryland (section 5) the Stromatopora horizon is at the middle of the Coeymans while the typical Gypidula galeata does not occur below the upper beds.

The New Scotland of all the sections is very similar, lithically and faunally. Spirifer macropleura (Conrad) is found in the whole formation in all the regions with the possible exception of the lower 20 feet of section 4 and the upper portion of section 2; in the latter, Gypidula pseudogaleata (Hall) is also present, thus closely resembling the Becraft. Edriocrinus pocilliformis Hall occurs in the lower beds of section 5 while it was not found earlier than the Becraft at Trilobite mountain.

The Becraft is a coarsely crystalline limestone (calcarenite) in sections 1, 2 and 3, containing many specimens of Gypidula pseudogaleata (Hall) and Spirifer concinnus Hall. In section 4 these beds will probably be found in the lower portion of the covered strata called Port Ewen, as the upper 20 feet of that section, correlated with the Becraft on stratigraphic grounds, are very similar both lithically and faunally to the uppermost New Scotland of section 3. No Gypidula pseudogaleata occurs in the Maryland section but Spirifer concinnus does; the latter species is thus found in all the sections, omitting section 4. Spirifer macropleura (Conrad) does not occur in the Becraft in any section.

The Port Ewen is not recognized in section 5, and is covered in section 4. In section 1 it is very similar lithically and faunally to the Coeymans, while in sections 2 and 3 it quite closely resembles in like characters the New Scotland.

The Oriskany of all the sections is more or less silicious. Some beds of section 2 and the upper Oriskany of section 5 are more distinctly sandstones. The fauna of sections 1 and 2 and the upper beds of 3 and 4 represent the calcareous facies of the normal Oriskany.[1] Sections 1 and 2 contain many more of the typical shallow water forms than do sections 3 and 4. The lower beds of sections 3, 4 and 5 contain an older Oriskany fauna. In the shallowing waters of the upper portion of the Oriskany of section 5 there was developed the normal Oriskany fauna.

As seen from the above sections, there is an increase in thickness of the upper Siluric and the lower Devonic strata from the north to the south, indicating a greater subsidence in the latter than in the former regions. These strata thin out westward in New York State, disappearing, with the exception of 7 feet of Manlius[2] and several inches of doubtful Oriskany sandstone, before Buffalo is reached. This is shown in the accompanying diagram [fig.4] taken from Hartnagel's report on the Cobleskill limestone of New York.[3]

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[1] See Oriskany under "General description of each horizon."

[2] Grabau, A. W. Siluro-Devonic Contact in N. Y. Geol. Soc. Am. Bul. 1900. p.347-76.

[3] Hartnagel, C. A. Preliminary Observations on the Cobleskill ("Coralline") Limestone of New York. N. Y. State Paleontol. An. Rep't. 1902. p.1109-75.

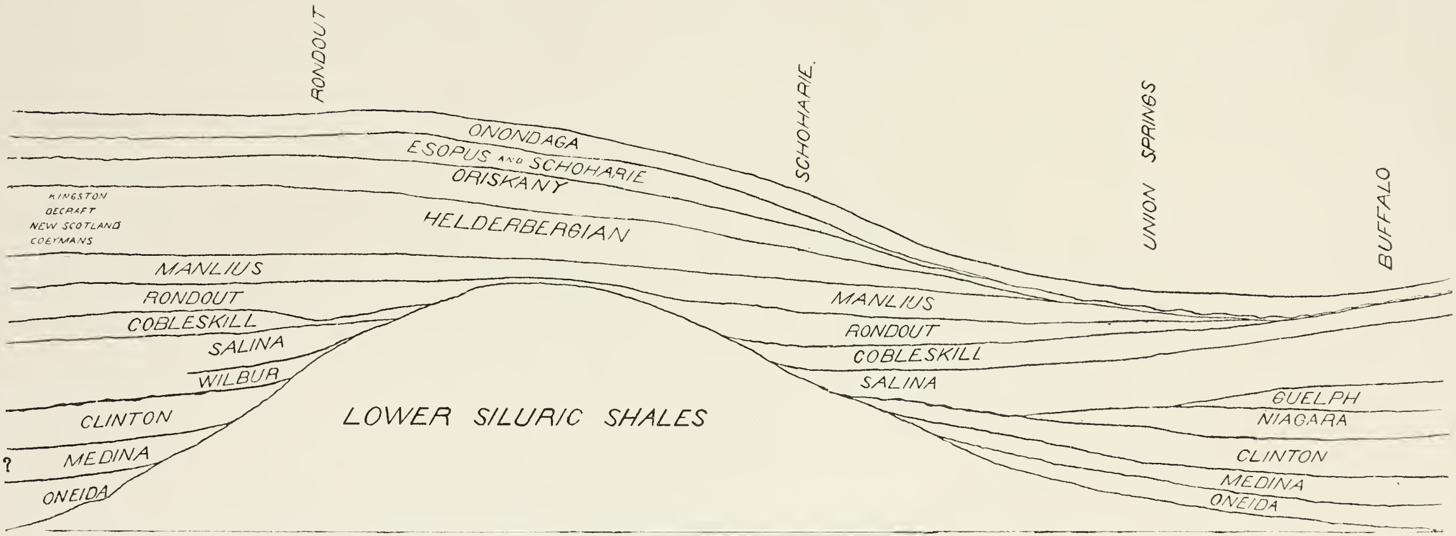

Fig. 4 Diagram showing overlaps and succession of formations of the Mississippian sea and an early stage of the Cumberland basin (After Hartnagel)

One of the most noticeable differences between the upper Siluric and lower Devonic formations of New York and Maryland is the greater development of limestones with the corresponding less development of shales in the latter region. In Maryland the clear water condition allowing the deposition of limestone began in the Salina and was continued almost without interruption to the Oriskany.[1] The Manlius fauna entered at the close of the Salina and continued during a deposit of over a hundred feet of strata; the land was, as during the Coeymans, at a considerable distance from the present exposed strata. During at least the upper New Scotland times, land was not far distant from any of the five sections, but it either soon sank again or a deflection of currents carried the muddy waters in another direction, allowing the deposition of the Becraft. In northwestern New Jersey and eastern New York, this was followed by a return of the New Scotland conditions, during which the Port Ewen was laid down.

During the Oriskany the shore line was again nearer, so that the deposit throughout the whole extent from Becraft mountain to western Maryland is a silicious limestone. At the close of this period the land rose both to the south and north. From the middle of Pennsylvania southward through western Maryland, land conditions existed, for the Marcellus rests on the eroded Oriskany;[2] but in New Jersey and New York the shore line after remaining near during a deposition of from 300 to 500 feet of the arenaceous shales of the Esopus, again retired to some distance, producing clear water, during which the heavily bedded Onondaga limestones were deposited. That this submergence took place slowly is indicated by the very gradual change from the Esopus to the Onondaga.

It is interesting to note that chert is prominently developed in the Coeymans and New Scotland in each of the five sections, i. e. from Becraft mountain in eastern New York to western Maryland.

Evidence of migration of faunas

Favosites helderbergiae praecedens occurs in the lowest Manlius of western Maryland. In New York and New

[1] Schuchert. On the Lower Devonic and Ontaric Formations of Maryland. U. S. Nat. Mus. Proc. 26:413-24.

[2] —— 1903. p.414.

Jersey F. helderbergiae is very abundant in the lowest Coeymans. In southern New York a few specimens have been noted in the upper Manlius.

Among bryozoa the genus Orthopora is recorded by Schuchert from the upper Manlius of Maryland. This is, according to Nickles and Bassler [1900] its earliest appearance. It is next found in the Helderbergian, where it is abundantly represented in the upper Coeymans and lower New Scotland of Trilobite mountain.

Gypidula galeata makes its first appearance in the upper Manlius of western Maryland as a small variety. This is here exceedingly abundant. It has not been found in the New York or New Jersey Manlius but the normal form appears in great numbers in the lower Coeymans; it is not present, however, in the Manlius-Coeymans transition (Favosites bed).

Leptocoelia flabellites occurs as a small variety in the Becraft of Maryland but not below the upper division of the Oriskany at Trilobite mountain.

Beachia suessana appears in the lower Oriskany of western Maryland as the variety immatura. These basal beds are probably contemporaneous with part of the Port Ewen of New York, since the latter are not recognized in Maryland and there was a continuous deposition. The first appearance of this species in New Jersey and New York was in the lower Oriskany.

These species appear to indicate a northward migration.

DETAILED DISCUSSION OF THE STRATA AND FAUNAS OF THE VARIOUS FORMATIONS AT TRILOBITE MOUNTAIN

Less than one eighth of a mile east of the tollgate which is at the southwest terminus of Trilobite mountain, is the road leading along the southeastern foot of the mountain. This may be called for convenience the Bennett road from the Bennett's limestone quarries which are situated by its side, and is, as noted on the sketch map, a public road for about one half the distance. Beyond this it is either a rough wood road or a mere foot path. It is along this road that the following sections begin, passing northwestward across the strike of the beds. The mountain, with the slight exception

of a few cleared fields, is covered with so dense a growth of shrubs and small trees that not only is traveling very difficult, but the rock outcrops are often concealed from view even at the distance of a few feet. This, together with the fact that most of the strata are covered with talus or drift, renders impossible the careful notation of successive beds and their fossil contents which one could wish. Another peculiarity of the region and one which makes the correlation of beds still more difficult, is the numerous hogbacks for which the mountain is justly noted. These as already noted are probably due to the greater or less development of certain cleavages over others, rendering the rock more susceptible to the disintegrating influences of the weather along the lines of the more pronounced cleavage. The length of the hogbacks is in the direction of the strike of the beds. At times when the hogback is very short, a well developed cleavage may obscure the strike.

The following sections are numbered from southwest to northeast along the Bennett road, beginning always on the northwest side of the road.[1]

Section A

This begins in a small quarry situated about 35 rods northeast of the junction of the Bennett road with the turnpike. This quarry was opened in the lower Oriskany since the sandy nature of the weathered rock renders it available for road material, though not eminently so.

A1 A dense, blue, very silicious limestone in coarsely shaly beds, weathering into a brown sandstone. Upper Port Ewen and Lower Oriskany .... 30 feet

The following fossils were found in the upper part:[2]

C=very common; c=common; r=rare; R=very rare.

85 Spirifer murchisoni *Castelnau*	137 Dalmanites *cf.* pleuroptyx
104 Actinopteria *cf.* communis	Crinoid joints

A2 Strata concealed by talus. Lower and Upper Oriskany. 125 feet

A3 Dark blue, thin bedded limestone. Upper Oriskany... 8 feet

[1] See local map.

[2] The numbering refers to the table at the end of the paper.

A4 Dark blue limestone in one bed. In the middle of this is a 3 inch, exceedingly fossiliferous band from which the following fossils were identified. Upper Oriskany. . . . . 1 foot

47 Coelospira dichotoma *Hall* c
48 Leptocoelia flabellites (*Conrad*) c
53 Meristella lata *Hall*
61 Orbiculoidea jervisensis (*Barrett*) ?
85 Spirifer murchisoni *Castelnau*
127 Tentaculites elongatus *Hall*

A5 Dense blue limestone containing many specimens of Tentaculites elongatus. In the basal portion of this is a chert band very similar to K33. Upper Oriskany. . . . . 10 feet

In the lower half of this outcrop were collected:

53 Meristella lata *Hall* ?
85 Spirifer murchisoni *Castelnau*
127 Tentaculites elongatus *Hall*

In the upper half:

30 Chonostrophia complanata *Hall*
34 Coelospira dichotoma (*Hall*)
85 Spirifer murchisoni *Castelnau* C

A6 Dense blue, upper Oriskany limestone extending to a band exceedingly full of large individuals of Tentaculites elongatus. This takes the section to the top of the hill bordering the Bennett road . . . . 10 feet

Section B

Section B begins about 95 rods northeast of section A, in a cleared field, or 8 rods southwest of an excellent spring (Pflaum's), which is easily noticed at the very edge of the western side of the road.

B1 Concealed strata. Upper New Scotland to Lower Port Ewen . . . . 210 feet

B2 Strata covered. Upper Port Ewen to Lower Oriskany. The last talus of the Trilobite bed was found at the top of this locality . . . . 100 feet

Few specimens of Dalmanites dentatus were found but many of the characteristic shells.

Section C

Section C begins about 30 rods northeast of section B, or 18 rods northeast of Pflaum's spring.

C1 Very finely grained, dark gray limestone; wherever it is weathered it is quite friable. This bed is very fossiliferous. Coeymans .... 6 feet

8 Favosites *sp.*
13 Lichenalia torta *Hall*
23 Atrypa reticularis (*Linnaeus*)
33 Coelospira concava (*Hall*)
40 Dalmanella subcarinata *Hall*
42 Eatonia medialis (*Vanuxem*)
44 Gypidula angulata *Weller* R
45 G. galeata (*Dalman*) C
57 Nucleospira elegans *Hall* ?
58 N. ventricosa *Hall* r
75 Rhynchonella semiplicata (*Conrad*) ?
76 Rhynchospira formosa *Hall* c
78 Schizophoria bisinuata *Weller* ?
79 S. multistriata *Hall* ?
82 Spirifer cyclopterus *Hall* C
88 Stropheodonta becki *Hall*
89 S. varistriata (*Conrad*) r
94 Strophonella punctulifera (*Conrad*)
98 Uncinulus mutabilis *Hall* c
99 U. nucleolatus *Hall* c
100 U. pyramidatus *Hall* c
110 Pterinea? naviformis *Conrad* R
123 Platyceras *sp.* R
129 Tentaculites *sp.*
137 Dalmanites pleuroptyx (*Green*) R
143 Proetus protuberans *Hall* R

C2 Rather coarsely grained limestone, usually in beds 1 to 3 feet thick. This extends up to the first chert band. Coeymans .... 15 feet

The most abundant fossils were:

8 Favosites *sp.*
45 Gypidula galeata (*Dalman*) C
52 Meristella laevis (*Vanuxem*) C
137 Dalmanites pleuroptyx (*Green*)

C3 A finer grained limestone than the preceding. The chert bands vary from ⅛ to 1 inch in thickness. Coeymans........ 9 feet

23 Atrypa reticularis (*Linnaeus*) c
45 Gypidula galeata (*Dalman*) c
52 Meristella laevis (*Vanuxem*) c
131 Orthoceras helderbergiae? *Hall* R
140 Phacops logani *Hall* R

C4 This limestone is similar to the preceding but contains more chert. The chert bands here vary from ½ inch to 2 inches in thickness and are from 1 to 2 inches apart. After weathering the chert is about as light as pumice stone. On the surfaces of partially weathered chert is an excellent place to note bryozoa. Lower New Scotland .... 11 feet

1 Hindia fibrosa? (*Roemer*)
5 Enterolasma strictum *Hall* c
8 Favosites *sp.*
13 Lioclema cellulosum? (*Hall*)
14 L. ponderosum (*Hall*) r
17 Orthopora regularis (*Hall*) c
18 O. rhombifera (*Hall*) C
20 Unitrypa praecursa (*Hall*)?
26 Bilobites varicus (*Conrad*) r
41 Delthyris perlamellosa *Hall* c
42 Eatonia medialis (*Vanuxem*) r

C5 Strata covered with talus. Lower New Scotland and Upper New Scotland . . . . 140 feet

C6 An outcrop of dark blue limestone is exposed on the brow of the hill. Upper New Scotland. . . . . 5 feet

5 Enterolasma strictum *Hall* r
40 Dalmanella subcarinata *Hall*
47 Leptaena rhomboidalis (*Wilckens*)
52 Meristella laevis (*Vanuxem*) r
62 Orthothetes woolworthanus *Hall*
71 Rhipidomella oblata *Hall*
82 Spirifer cyclopterus *Hall* C
88 Stropheodonta becki *Hall*
90 S. varistriata *var.* arata *Hall*

Section D

This section begins 15 rods northeast of section C, or 34 rods northeast of Pflaum's spring in the large Bennett quarry.

D1 Dense, compact, dark blue almost black limestone. A finely grained variety alternates with one rather coarsely grained in beds

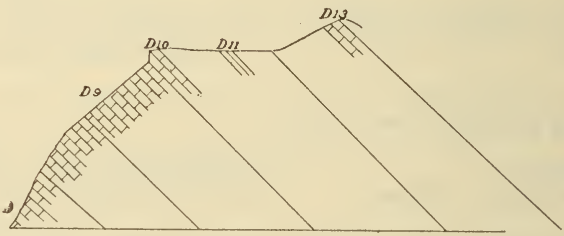

Fig. 5 Section D

from 1 to 6 inches thick, separated by almost black shale seams; these latter vary in thickness from a fraction of an inch to an inch and are very irregular; the thinner ones at times even present an appearance similar to cranial sutures. The thicker ones are not so irregular but are rather as though molded over little hillocks. These shale seams are often separated from the rock above and below by calcite seams, the crystallization of which is vertical to the bedding plane; at times even the laminae of the shale are farther separated thus. There are quite coarsely grained layers, specially toward the upper part of this locality; these are usually only 1 to 3 inches in thickness; the last one of these occurs about 2 feet below the base of the Favosites bed. . . . . 20 feet

The following is a more detailed subdivision of the above from the base upward.

D1a Alternately fine and medium grained limestone with many irregular shale seams. It contains many minute crystals of iron pyrites. Upper Manlius .... 5 feet

These fossils were found here,—

7 Favosites sphaericus *Hall*	103 Whitfieldella? nucleolata (*Hall*)
Sphaerocystites multifasciatus? *Hall* c	Euomphalus? R
16 Monotrypella? abrupta? (*Hall*)	116 Loxonema *sp.*
Atrypa *sp.*	124 Pleurotomaria *sp.*
86 Spirifer vanuxemi *Hall*	128 Tentaculites gyracanthus (*Eaton*) c
89 Stropheodonta varistriata (*Conrad*) r	135 Dalmanites micrurus (*Green*)
	144 Beyrichia manliusensis *Weller* r
	145 B. *sp.* c

D1b Rather coarse grained with small and scattered particles of chert; at times the chert is absent for several horizontal feet .... 6 inches

D1c Alternating fine and medium grained limestone..... 6 feet

86 Spirifer vanuxemi *Hall* c	128 Tentaculites gyracanthus (*Eaton*) r
89 Stropheodonta varistriata (*Conrad*) C	145 Beyrichia *sp.*
103 Whitfieldella? nucleolata (*Hall*) c	

D1d Medium grained with very small particles of chert scattered through the bed.................................. 6 inches

86 Spirifer vanuxemi *Hall*	108 Megambonia aviculoidea *Hall* r
89 Stropheodonta varistriata (*Conrad*)	

D1e Alternately fine and rather coarse grained limestone .... 2 feet, 4 inches

86 Spirifer vanuxemi *Hall*	103 Whitfieldella? nucleolata (*Hall*)
89 Stropheodonta varistriata (*Conrad*)	

D1f Fine grained limestone which shows good sub-bedding; specially is this seen where the rock has been exposed to atmospheric agencies since glacial times. Here the laminae stand out with tissue paperlike thinness. A corresponding development of sub-bedding was not noticed in any of the other beds, perhaps because none of them had apparently been weathered for the same length of time .... 3 feet

86 Spirifer vanuxemi *Hall*
89 Stropheodonta varistriata (*Conrad*)
102 Uncinulus *sp.*

D1g Alternating coarse and fine grained limestone.... 32 inches

6 Favosites helderbergiae *Hall* r
86 Spirifer vanuxemi *Hall* r
89 Stropheodonta varistriata (*Conrad*) r
103 Whitfieldella? nucleolata (*Hall*)
146 Leperditia alta (*Conrad*) c

D2 Favosites bed. From one to several inches below the base of this bed is a shale seam from ⅛ to ¾ inch in thickness; but above the seam the lithic character of the rock is the same as beneath it, that is, a fine grained dark blue limestone similar to the lower portion of D1a. This extends up between the heads of the Stromatopora and Favosites which suddenly become very numerous.. 3 feet

This bed is subdivided as follows:

D2a This is made up almost entirely of masses of Stromatopora and Favosites; the interspaces between these are filled with a fine grained, dark blue limestone. Stromatopora individuals are greatly in excess of all other fossils. Specimens of Favosites partially surrounded by Stromatoporoid growths and vice versa are quite common. This layer is specially noticeable when weathered; the concentrically wrinkled laminae of the hydrozoon stand out then very conspicuously. The Stromatoporoid masses vary in diameter from 2 to 9 inches.............................. 9-10 inches

The following fossils were found:

2 Stromatopora concentrica? *Goldfuss* C
6 Favosites helderbergiae *Hall* C
7 F. sphaericus *Hall* C
9 Zaphrentis roemeri *Edwards & Haime* r

D2b First crinoidal bed. The rock is coarse grained through the presence of very many crinoid joints. No Stromatoporas were noticed here, but Favosites is still present, though in greatly diminished numbers .... 1+ foot

7 Favosites sphaericus *Hall* C
89 Stropheodonta varistriata (*Conrad*) r

D2c A fine grained limestone very similar to D2a. Where this layer is absent it is represented by a weathered line of separation..

No fossils were noticed.............................. 1-2 inches

D2d Second crinoidal bed. Same character of limestone as D2b. The only fossils seen here were Favosites sphaericus Hall which was very abundant, and F. helderbergiae Hall which was rare.. 1 foot

D2e Iron stain.. a line

The entire Favosites bed is always closed by a line of iron stain. This is not a perfectly straight line but will at times rise a half foot above a Favosites head. The succeeding bed is very full of specimens of Gypidula galeata resting often immediately on the iron stain but never, as far as noticed, occurring below this. Specimens of Favosites occur in the higher beds, but very rarely as compared with their abundance in the Favosites bed. The line where the iron stain occurs weathers into an open seam.

D3 This bed succeeds the iron stain and but for the very great number of individuals of Gypidula galeata present would have been placed in the upper band of the Favosites bed. This stratum becomes gradually more finely crystalline till the characteristic rock of bed D4 occurs. Coeymans............. 1-6 inches

6 Favosites helderbergiae *Hall* c	45 Gypidula galeata (*Dalman*) c
23 Atrypa reticularis (*Linnaeus*) r	

D4 Very finely crystalline limestone. Few fossils and these mostly specimens of Gypidula galeata. Coeymans.. 2½-3 feet

D5 Limestone, very coarsely crystalline from the abundance of crinoid joints and broken shells present. The lower portion is specially full of individuals of Gypidula galeata. Coeymans .... 4¼ feet

7 Favosites sphaericus *Hall* c	88 Stropheodonta becki *Hall* c
12 Lichenalia torta *Hall* r	98 Uncinulus mutabilis *Hall* r
23 Atrypa reticularis (*Linnaeus*) r	102 U. *sp.*
45 Gypidula galeata (*Dalman*) C	123 Platyceras *sp.* R

D6 Bed D5 changes suddenly to a friable, finely grained rock. Coeymans .... 9 feet

23 Atrypa reticularis (*Linnaeus*) r	45 Gypidula galeata (*Dalman*) c

D7 A rather coarsely crystalline limestone very similar to D5 Coeymans .... 11½ feet

D8 A rather finely crystalline gray limestone containing numerous chert bands. The chert appears here for the first time since leaving locality D1. Lower New Scotland.................... 30½ feet

5 Enterolasma strictum *Hall* c
33 Coelospira concava (*Hall*) r
40 Dalmanella subcarinata *Hall*
41 Delthyris perlamellosa *Hall* c
42 Eatonia medialis (*Vanuxem*) R
47 Leptaena rhomboidalis (*Wilckens*)
52 Meristella laevis (*Vanuxem*) c
54 M. princeps *Hall* R
74 Rhynchonella bialveata? *Hall*
76 Rhynchospira formosa *Hall* R
121 Platyceras tenuiliratum *Hall* R

D9 Strata covered with talus. Lower New Scotland to Upper New Scotland .... 132 feet

D10 Gray shale. Upper New Scotland .... 10 feet

5 Enterolasma strictum *Hall* r
12 Lichenalia torta *Hall* R
33 Coelospira concava (*Hall*) c
40 Dalmanella subcarinata *Hall* r
42 Eatonia medialis (*Vanuxem*) r
72 Rhipidomella tubulistriata *Hall* R
82 Spirifer cyclopterus *Hall* c
123 Platyceras *sp.*
138 Dalmanites *sp.* R

D11 Concealed strata. Upper New Scotland, Becraft and Port Ewen .... 95 feet

D12 Blue limestone containing some chert. Port Ewen.. 5 feet

5 Enterolasma strictum *Hall*
12 Lichenalia torta *Hall*
53 Meristella lata *Hall*
94 Strophonella punctulifera (*Conrad*)

D13 Strata covered with soil take us to the top of a hogback which is formed of a finely grained, dark blue, very hard limestone which weathers first into a brown sandstone and then into a coarse yellow clay. Port Ewen .... 75 feet

D14 Strata covered take to the Trilobite bed. Port Ewen and Lower Oriskany .... 100 feet

D15 Concealed strata take to the swamp. Upper Oriskany .... 90 feet

Section E

Section E begins about 20 rods northeast of section D in a small, abandoned quarry in the Upper Manlius.

E1 Manlius .... 31 feet

This is subdivided as follows:

E1a A coarsely grained blue limestone. Lower Manlius.. 1 foot

E1b A quite finely grained blue limestone, with narrow calcite veins, capped by a 2 inch band very full of specimens of Stropheodonta varistriata (Conrad). Lower Manlius 3½ feet

E1c Limestone similar to the last. Few fossils. Lower Manlius .... 11 inches

E1d Tentaculite band. Specimens of Tentaculites gyracanthus (Eaton) are very abundant here. This band varies greatly in thickness, being at times represented by merely a superficial layer of the shells. Here were also found Megambonia aviculoidea Hall R and Beyrichia manliusensis Weller r. Lower Manlius.............................. ½ inch

E1e Finely grained, dark blue limestone, usually in 1 inch beds separated by black shale seams. Lower Manlius......... 6 inches

E1f A blue limestone of medium grain from which the following fossils were identified. Lower Manlius..................... 1 foot

89 Stropheodonta varistriata (*Conrad*) c	128 Tentaculites gyracanthus (*Eaton*) R
	146 Leperditia alta *Conrad* R

E1g Finely grained limestone with thin and very irregular shale seams. The upper foot is quite fossiliferous. Upper Manlius .... 3 feet

From it were identified:

86 Spirifer vanuxemi *Hall* R	103 Whitfieldella? nucleolata (*Hall*) c
89 Stropheodonta varistriata (*Conrad*) R	

E1h Limestone similar to the preceding. Upper Manlius .... 3¾ feet

86 Spirifer vanuxemi *Hall*	116 Loxonema *sp.*
103 Whitfieldella? nucleolata (*Hall*)	128 Tentaculites gyracanthus (*Eaton*)

E1k A rather finely grained limestone which is very fossiliferous. The rock is very full of gastropod shells which are closely similar to Loxonema or Holopea; but as they are very coarsely crystalline it is almost impossible to get them from the rock. Upper Manlius .... 3 inches

86 Spirifer vanuxemi *Hall* r
89 Stropheodonta varistriata (*Conrad*) c
103 Whitfieldella? nucleolata (*Hall*) c
Loxonema?
144 Beyrichia manliusensis *Weller* r
146 Leperditia alta *Conrad* r

E1l A rather finely grained limestone. Upper Manlius.. 2¼ feet

89 Stropheodonta varistriata (*Conrad*) c
103 Whitfieldella? nucleolata (*Hall*) r
114 Holopea antiqua? (*Vanuxem*) c

E1m A rather coarsely grained limestone which is quite fossiliferous. A little chert was noticed in the lower portion. Upper Manlius .... 15 inches

89 Stropheodonta varistriata (*Conrad*) C
103 Whitfieldella? nucleolata (*Hall*) r
114 Holopea antiqua? (*Vanuxem*) c
144 Beyrichia manliusensis *Weller* R

From E1m to the base of the Favosites bed no strata are exposed. Upper Manlius .... 13 feet

Section F

A few rods northeast of the last section is a large abandoned quarry in the center of which this section begins.

F1 The Manlius is here separated into an outer and an inner portion by an old quarry floor. It is possible that the outer portion represents a block of the same rock as the inner, that, undermined by the larger stream that formerly flowed through this valley, has fallen to its present position. Such fallen blocks occur ¼ of a mile farther to the northeast at what is locally known as the Ramapo Hole.

Though this explanation is possible it does not seem probable. The strike and dip are the same for both portions of this locality. The fossils also indicate that the rocks are from different horizons. The outer portion (F1) has a thickness of 13 feet and is much weathered. It has the same lithic character as E1. No chert band was noticed. The following is a detailed subdivision from the base upward. Lower Manlius.

F1a Dark blue limestone. Lower Manlius............. 1 foot

F1b Gnarled bed. A concretionary, dark blue limestone, composed almost wholly of nodules varying in diameter from ⅛ inch to 1 inch, which on weathered surfaces are shown to be Stromatoporoid

masses. This appears to be structurally similar to Stromatopora bed 3 at Becraft mountain.[1] Weller also notes the occurrence of Stromatoporoid masses over 30 feet beneath the Favosites bed.[2]

Lower Manlius.. 5 feet

F1c Finely grained limestone. Lower Manlius......... 1 foot

F1d Lower 2 inches are a finely grained limestone, the rest is coarse. Both portions contain Spirifer vanuxemi Hall and Beyrichia manliusensis Weller in abundance. Leperditia alta Conrad and Loxonema sp. were occasionally found. Lower Manlius......................... 1 foot

F1e Very finely grained blue limestone, in which Spirifer vanuxemi Hall is very abundant. A few specimens of Leperditia alta Conrad were also found. Lower Manlius.. 1 foot

F1f Alternately fine and coarse grained blue limestone inclosing some shale bands. The following species, but not in abundance, were found here. Lower Manlius.................... 32 inches

86 Spirifer vanuxemi *Hall*	116 Loxonema *sp.*
89 Stropheodonta varistriata? (*Conrad*)	144 Beyrichia manliusensis? *Weller*
	146 Leperditia alta *Conrad*

F1g Dark blue limestone. Lower Manlius........... 4 inches

F1h Light gray limestone with many specimens of Spirifer vanuxemi Hall and Stropheodonta varistriata (Conrad). No other fossils were noticed. Lower Manlius.. 1 inch

F1k Dark gray limestone. No fossils found.......... 5 inches

F1l Dark blue limestone exceedingly full of specimens of Spirifer vanuxemi Hall and Stropheodonta varistriata (Conrad). Lower Manlius................. 2 inches

F1m Alternating finely and coarsely grained, dark blue limestone. It has many conspicuous shale seams. Lower Manlius.... 4½ feet

The following fossils were collected:

86 Spirifer vanuxemi *Hall* C	128 Tentaculites gyracanthus (*Eaton*) c
89 Stropheodonta varistriata (*Conrad*) r	144 Beyrichia manliusensis *Weller* r

F1n A finely crystalline, dark blue limestone with alternating shale seams. Five inches from the top is a 1 inch band of which

[1] Grabau, A. W. Stratigraphy of Becraft Mountain, Columbia County, N. Y., N. Y. State Paleontol. An. Rep't 1902, p.1052.

[2] Weller. Geol. Sur. N. J. 3:78.

the lower and upper quarter inches are usually in large measure composed of Tentaculites gyracanthus (Eaton). Lower Manlius .... 20 inches

The following is a list of the fossils noticed here:

86 Spirifer vanuxemi *Hall*	145 Beyrichia *sp.*
128 Tentaculites gyracanthus (*Eaton*)	146 Leperditia alta *Conrad*

F1p Between cliffs F1n and F1q there is no outcrop. Upper Manlius .... 21 feet

F1q A dark gray limestone weathering dark blue. Lithologically it is quite similar to F1a-n but it is much less weathered. No fossils were found in the lower portion but in the upper 1½ feet were found Whitfieldella? nucleolata (Hall) C and Spirifer vanuxemi *Hall* r. Upper Manlius.................. 7 feet

All of F1 is very coarsely grained and apparently much more fossiliferous but this may be largely due to greater weathering.

F2 The "Favosites Bed" as in section D begins suddenly after 2 or 3 inches of a finely grained limestone have been laid down on ½ inch shale band.................................. 3 feet

The following is the subdivision of F2. It is similar to that of section D.

F2a Many specimens of Stromatopora concentrica? Goldfuss and a few of Favosites helderbergiae Hall, separated by finely grained limestone, make up most of this layer. Whitfieldella? nucleolata (Hall) is represented by a few specimens from the basal 3 or 4 inches. Fragments of undetermined Ostracods, probably of Beyrichia, are scattered through the bed.................................. 9-10 inches

F2b First crinoidal bed. This is similar in lithic character to D2b. The rock weathers easily at the juncture of F2a and F2b. Favosites helderbergiae Hall is quite abundant. Stromatopora concentrica? Goldfuss is rather rare. Besides these fossils several specimens of Lichenalia torta Hall and a pygidium of Dalmanites pleuroptyx (Green) were found.................................. 14 inches

F2c This lettered layer of locality D is absent here but its place is indicated by a line of weathering.

F2d Second crinoidal bed. This is lithologically similar to D2d . . . . 1 foot

The following fossils were found:

2 Stromatopora concentrica? *Goldfuss* r
6 Favosites helderbergiae *Hall* C
7 F. sphaericus? *Hall*

F2e Iron stain. Though other iron stain lines are noticeable at intervals, one can not mistake this one as it is the most continuous and most pronounced.

With the exception of Whitfieldella? nucleolata, brachiopods seem to be entirely wanting in the Favosites bed, but immediately above they are very abundant. This is the more notice-

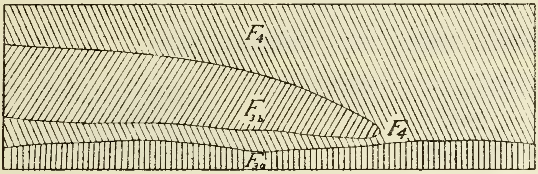

Fig. 6 Diagram of section F

able since the lower part of F3 and the upper part of F2d have the same lithic characters and often weather as a single bed.

F3 An alternation of coarsely and finely crystalline limestone. Coeymans . . . . 1-7 inches

The following is a list of the fossils found here:

6 Favosites helderbergiae *Hall* C
12 Lichenalia torta *Hall* c
23 Atrypa reticularis (*Linnaeus*) r
45 Gypidula galeata (*Dalman*) c
89 Stropheodonta varistriata (*Conrad*)
90 S. varistriata *var.* arata *Hall*
94 Strophonella punctulifera (*Conrad*)
102 Uncinulus *sp.*

This bed is subdivided as follows:

F3a A coarsely grained limestone mostly composed of crinoid joints, which seems to be a modified continuation of F2d. A few brachiopods were noticed. . . . . 1-3 inches

F3b This is of the same lithic character as F4 and doubtless represents the beginning of the latter bed, but the conditions changing brought the typical F3 sediment in again, for at the northern end of the quarry, F4 rests on F3a but as we follow F4 southward, we find it penetrated by a more coarsely grained layer which at the southern end of the quarry attains a thickness of 3 inches. This is represented in the preceding figure [fig.6] . . . . 1-3 inches

F4 A finely grained gray limestone. The fossils are comparatively much less abundant than in either the preceding or succeeding bed. Coeymans . . . . 3 feet

The following is a list of the fossils:

7 Favosites sphaericus *Hall* r
12 Lichenalia torta *Hall* c
45 Gypidula galeata (*Dalman*) c
89 Stropheodonta varistriata? (*Conrad*) R
102 Uncinulus *sp.*
123 Platyceras *sp.* R

F5 A coarsely grained, dark gray limestone made up in great part of large crinoid joints. Most of the grains are surrounded by a coating of limonite. Coeymans . . . . 4½ feet

The following fossils were obtained here:

6 Favosites helderbergiae *Hall* C
7 F. sphaericus *Hall* c
12 Lichenalia torta *Hall* r
45 Gypidula galeata (*Dalman*) C
G. galeata *var.*
88 Stropheodonta becki *Hall*

F6 Alternately finely and coarsely grained limestone. Coeymans . . . . 20 feet

This is subdivided as follows:

F6a Finely grained similar to F4. 15 inches

F6b Coarsely grained similar to F5. . . . . 8 inches

F6c Finely grained, friable. . . . . 5 inches

F6d Very coarsely grained. Favosites helderbergiae Hall is common here. . . . . 4½ feet

F6e Finely grained limestone, at times shaly. . . . . 10 inches

F6f Very coarsely grained. . . . . 3½ feet

Here were found:

12 Lichenalia torta *Hall* r
40 Dalmanella subcarinata *Hall* r
45 Gypidula galeata (*Dalman*) c

F6g A rather coarsely grained limestone. The upper foot and a half is at times exceedingly coarse grained, with limonite surrounding each grain where weathered. . . . . 9 feet

The following fossils were found here:

5 Enterolasma strictum *Hall* c
8 Favosites *sp.*
23 Atrypa reticularis (*Linné*) r
44 Gypidula galeata (*Dalman*) C

58 Nucleospira ventricosa *Hall* r
75 Camarotoechia semiplicata (*Conrad*) r
89 Stropheodonta varistriata (*Conrad*) R

F7 This stratum is characterized by many chert bands which vary in width from a mere line to 2 inches................ 26 feet

This is subdivided as follows:

F7a A very dark blue limestone with a few bands of chert. Fossils were not abundant. The only species found were Enterolasma strictum Hall c and Gypidula galeata (Dalman) c. Coeymans......................... 5 feet 4 inches

F7b Blue shaly limestone weathering to a very light chocolate color. Coeymans .... 1 foot

5 Enterolasma strictum *Hall* c
45 Gypidula galeata (*Dalman*) c
47 Leptaena rhomboidalis (*Wilckens*) c

F7c Very dense, dark blue limestone with very many chert bands which, when weathered, furnish excellent bryozoa. The chert of the preceding beds even when weathered shows little else than crinoid joints and comparatively few of these. Coeymans.. 4 feet 4 inches

The following fossils were collected here, most of them from the weathered surfaces of the chert bands:

5 Enterolasma strictum *Hall* c
12 Lichenalia torta *Hall* r
13 Lioclema cellulosum (*Hall*) c
17 Orthopora regularis (*Hall*) c
18 O. rhombifera (*Hall*) C
19 Unitrypa nervia (*Hall*) r
20 U. praecursa (*Hall*) c
33 Coelospira concava *Hall* r
37 Cyrtina *sp.* R
39 Dalmanella perelegans *Hall* r
40 D. subcarinata *Hall* c
41 Delthyris perlamellosa *Hall* c
45 Gypidula galeata (*Dalman*) c
47 Leptaena rhomboidalis (*Wilckens*)
Orbiculoidea *sp.*
63 Pholidops ovata *Hall* c
68 Reticularia modesta (*Hall*) r
71 Rhipidomella oblata *Hall* R
73 Camarotoechia altiplicata? *Hall* R
77 Rhynchospira globosa? *Hall* r
88 Stropheodonta becki *Hall* r
136 Dalmanites nasutus? *Conrad* R

F7d Dense, dark blue limestone full of chert bands. Lower New Scotland .... 15½ feet

The following fossils were collected:

5 Enterolasma strictum *Hall* C
7 Favosites sphaericus *Hall* r
26 Bilobites varicus (*Conrad*) r
40 Dalmanella subcarinata *Hall* c

82 Spirifer cyclopterus *Hall* r
S. octocostatus? *Hall* R
88 Stropheodonta becki *Hall* r
140 Phacops logani *Hall* r

F8 Talus concealing strata. Lower to Upper New Scotland .... 72 feet

F9 An outcrop of slaty shale exposed in a dug road. Upper New Scotland .... 5 feet

Following is a list of fossils found here:

5 Enterolasma strictum *Hall* c
33 Coelospira concava (*Hall*) C
40 Dalmanella subcarinata *Hall* c
41 Delthyris perlamellosa *Hall* c
42 Eatonia medialis (*Vanuxem*) c
47 Leptaena rhomboidalis (*Wilckens*) c
52 Meristella laevis (*Vanuxem*) c
58 Nucleospira ventricosa? *Hall* R
62 Orthothetes woolworthanus *Hall* r
71 Rhipidomella oblata *Hall* r
73 Camaratoechia altiplicata? *Hall* R
82 Spirifer cyclopterus *Hall* C
83 S. macropleura (*Conrad*) C
94 Strophonella punctulifera (*Conrad*) r
95 Trematospira multistriata *Hall* c
102 Uncinulus *sp.*

F10 Unexposed strata. Upper New Scotland to Lower Oriskany .... 298 feet

F11 Trilobite bed. Lower Oriskany................ 6 inches

A low ledge which yielded the following fossils:

25 Beachia suessana *Hall* c
47 Leptaena rhomboidalis (*Wilckens*) c
115 Loxonema jerseyense *Weller* r
135 Dalmanites dentatus *Barrett* C

F12 Unexposed strata. Upper Oriskany............. 62 feet

This extends to the edge of the swamp.

Section G

Section G begins 15 rods northeast of section F.

G1 Upper Manlius.................................. 19 feet

Subdivided as follows:

G1a A finely grained, blue limestone. Few fossils...... 4½ feet

G1b Tentaculite layer. Tentaculites gyracanthus (Eaton) is exceedingly abundant......................... 1 inch

G1c Thin bands of a dark blue limestone, averaging one inch in thickness, alternating with thinner bands of shale. This begins with

a half inch shale seam lying immediately on the Tentaculite band .... 10 inches

G1d The lowest portion is a 3 foot bed of solid limestone. This is succeeded by a rather shaly limestone, 2 to 4 inches thick, alternating with thin shaly seams, ¼ to ½ inch thick......... 11½ feet

The following fossils were gathered here:

86 Spirifer vanuxemi *Hall* C
89 Stropheodonta varistriata (*Conrad*)
103 Whitfieldella? nucleolata (*Hall*) C
116 Loxonema *sp.*
128 Tentaculites gyracanthus (*Eaton*)
144 Beyrichia manliusensis? *Weller* r

G1e Chert is sparingly scattered through the lowest layer of this .... 2 feet

Section H

Section H begins 5 rods northeast of section G.

H1 Upper Manlius................................ 13 feet

H1a An exceedingly dense, finely grained, dark gray limestone with very few fossils. Even where weathered from preglacial times, there are very few fossil fragments shown................ 11 feet

H1b Alternately finely and rather coarsely grained, dark gray limestone .... 2 feet

Fossils are much more abundant than in the preceding bed. The following were identified:

Favosites?
86 Spirifer vanuxemi *Hall* r
103 Whitfieldella? nucleolata (*Hall*) C
116 Loxonema *sp.*
144 Beyrichia manliusensis? (*Weller*) r
146 Leperditia alta (*Conrad*) c

H2 Favosites bed. The lower 4 inches weather quite red. The whole bed is full of Stromatopora heads.................... 1 foot

The following fossils were identified:

2 Stromatopora concentrica? *Goldfuss* C
6 Favosites helderbergiae *Hall* c
7 F. sphaericus *Hall* r
64 Rensselaeria *cf.* aequiradiata (*Conrad*) R
89 Stropheodonta varistriata (*Conrad*)
103 Whitfieldella? nucleolata (*Hall*) r

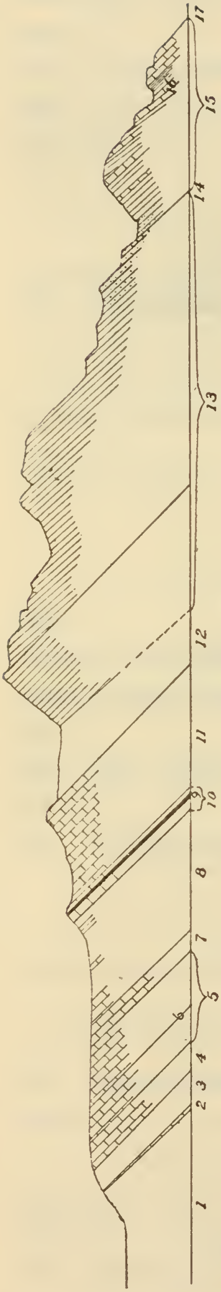

Fig. 7 Section K

Section K

This section begins 12 rods northeast of section H where a lane turns up the hill leading to the residence of Mr William Balmos.

K1 Uppermost Manlius immediately below the Favosites bed....................2 feet

K2 Unexposed strata. Favosites bed to Lower New Scotland................50 feet

K3 Very finely grained, cherty, blue limestone. Lower New Scotland..........6 feet

The following fossils were identified from this locality:

41 Delthyris perlamellosa *Hall* c
42 Eatonia medialis (*Vanuxem*)
47 Leptaena rhomboidalis (*Wilckens*)
50 Lingula *sp.*
52 Meristella laevis (*Vanuxem*)
113 Diaphorostoma ventricosum (*Conrad*) R
140 Phacops logani *Hall* r

K4 Thin bedded, dark gray shale. One foot from the base is a half inch band of light gray sandstone. Lower New Scotland.......
2 feet, 4 inches

42 Eatonia medialis (*Vanuxem*) C
43 E. singularis (*Vanuxem*) r
50 Lingula *sp.*
52 Meristella laevis (*Vanuxem*) r
Orbiculoidea *sp.*
88 Stropheodonta becki *Hall*
92 Strophonella headleyana *Hall*
132 Orthoceras *sp.*

K5 Dense, dark blue limestone. Lower New Scotland....................15 inches

5 Enterolasma strictum *Hall* c
8 Favosites *sp.*
40 Dalmanella subcarinata *Hall*
41 Delthyris perlamellosa *Hall* r

42 Eatonia medialis (*Vanuxem*) r
52 Meristella laevis (*Vanuxem*) c
71 Rhipidomella oblata *Hall*
92 Strophonella headleyana *Hall*

K6 An arenaceous limestone. Lower New Scotland... 5 inches

16 Monotrypella? abrupta (*Hall*) c
21 Vermipora serpuloides *Hall* c
24 Atrypina imbricata? *Hall*
33 Coelospira concava *Hall* c
40 Dalmanella subcarinata *Hall*
52 Meristella laevis (*Vanuxem*) R
60 Orbiculoidea discus? *Hall* R
68 Reticularia modesta (*Hall*)
71 Rhipidomella oblata *Hall*

K7 Following is given the detailed subdivision from the base upward. Lower New Scotland................ 2 feet, 8½ inches

K7a Dense, blue limestone in several thin beds...... 7½ inches

K7b Black shale.............................. ⅛ inch

K7c Light gray sandstone........................ ⅞ inch

K7d Dense, dark blue limestone in 4 to 6 inch beds, including in the middle a 1 inch shaly limestone...................... 2 feet

The following fossils were identified from K7:

1 Hindia fibrosa? (*Roemer*) R
28 Chonetes hudsonicus *Clarke*
40 Dalmanella subcarinata *Hall*
41 Delthyris perlamellosa? *Hall* R
47 Leptaena rhomboidalis (*Wilckens*)
50 Lingula *sp.*
52 Meristella laevis (*Vanuxem*) C
56 Nucleospira concentrica *Hall*
71 Rhipidomella oblata *Hall*
83 Spirifer macropleura? (*Conrad*) R
104 Actinopteria communis (*Hall*) R

K8 A dark gray, very fossiliferous shale including microscopic films of a black shale. This latter at times constitutes the main rock mass. Three inches from the top is a 3 inch sandstone band. Lower New Scotland............................ 21 inches

40 Dalmanella subcarinata *Hall*
41 Delthyris perlamellosa *Hall* c
43 Eatonia singularis (*Vanuxem*) c
47 Leptaena rhomboidalis (*Wilckens*)
52 Meristella laevis (*Vanuxem*) C
54 M. princeps *Hall* R
83 Spirifer macropleura (*Conrad*) C

K9 This is subdivided from base upward as follows. Lower New Scotland .... 6 feet, 7 inches

K9a Dark gray, sandy, calcareous shale in 2 inch beds.. 15 inches

K9b Chert band................................ 1 inch

K9c Dark gray, calcareous shale including a limestone of varying thickness .... 2 feet

K9d Shale including in the middle a 6 inch limestone stratum and at intervals a thin chert band.................... 3 feet, 3 inches

40 Dalmanella subcarinata *Hall*
41 Delthyris perlamellosa *Hall* R
43 Eatonia singularis (*Vanuxem*)
47 Leptaena rhomboidalis (*Wilckens*)
50 Lingula *sp.*
52 Meristella laevis (*Vanuxem*) c
83 Spirifer macropleura (*Conrad*) c
95 Trematospira multistriata *Hall* r
117 Platyceras *cf.* gibbosum *Hall* R
123 P. *sp.* R

K10 A dark gray, calcareous shale. Lower New Scotland .... 2 feet, 8 inches

40 Dalmanella subcarinata *Hall*
47 Leptaena rhomboidalis (*Wilckens*)
83 Spirifer macropleura *Conrad* R
113 Diaphorostoma ventricosum (*Conrad*) R
140 Phacops logani *Hall* R

K11 Strata concealed. Lower New Scotland........ 12½ feet

K12 A dark blue, much cleaved shale, which weathers to a brownish yellow clay. Upper New Scotland.................. 42 feet

K12a Comprises the lower......................... 28 feet

The following fossils were found here:

24 Atrypina imbricata *Hall* c
33 Coelospira concava *Hall* r
40 Dalmanella subcarinata *Hall*
41 Delthyris perlamellosa *Hall* R
42 Eatonia medialis (*Vanuxem*) r
43 E. singularis (*Vanuxem*) R
47 Leptaena rhomboidalis (*Wilckens*)
50 Lingula *sp.* c
52 Meristella laevis (*Vanuxem*) c
63 Pholidops ovata *Hall* r
64 Rensselaeria *cf.* aequiradiata (*Conrad*)
82 Spirifer cyclopterus *Hall* r
83 S. macropleura (*Conrad*) R
88 Stropheodonta becki *Hall*
92 Strophonella headleyana *Hall*

The Lingulas occur in calcareous, phosphatic, clay nodules. No manganese was detected in the nodules. Hall[1] notes the occurrence of the nodules and their "uniformly elongated oval or ovoid form" in the New Scotland in Albany county, N. Y.

K12b Comprises the upper.......................... 14 feet

33 Coelospira concava *Hall* c
40 Dalmanella subcarinata *Hall*
41 Delthyris perlamellosa? *Hall* R
47 Leptaena rhomboidalis (*Wilckens*)
52 Meristella laevis (*Vanuxem*) r
83 Spirifer macropleura (*Conrad*)
127 Tentaculites elongatus *Hall* R

[1] Pal. N. Y. 3:158.

K13 Concealed strata. Upper New Scotland.......... 17 feet

K14 A dense, blue, more or less shaly limestone, subdivided as follows. Upper New Scotland......................... 35 feet

K14a Rather coarsely shaly......................... 18 feet

33 Coelospira concava *Hall*
40 Dalmanella subcarinata *Hall*
41 Delthyris perlamellosa *Hall* r
47 Leptaena rhomboidalis (*Wilckens*)
79 Schizophoria multistriata *Hall* R
82 Spirifer cyclopterus *Hall* c
88 Stropheodonta becki *Hall*

K14b The limestone becomes quite heavy bedded........ 6 feet

33 Coelospira concava *Hall* c
41 Delthyris perlamellosa? *Hall* c
47 Leptaena rhomboidalis (*Wilckens*)
52 Meristella laevis (*Vanuxem*) c
82 Spirifer cyclopterus *Hall* c
83 S. macropleura (*Conrad*) r
88 Stropheodonta becki *Hall* r
96 Trematospira perforata? *Hall*
100 Uncinulus pyramidatus *Hall* R

K14c Shaly limestone similar to K14a................. 8 feet

40 Dalmanella subcarinata *Hall*
41 Delthyris perlamellosa *Hall* c
47 Leptaena rhomboidalis (*Wilckens*)
52 Meristella laevis (*Vanuxem*) r
71 Rhipidomella oblata? *Hall*
82 Spirifer cyclopterus *Hall* c
83 S. macropleura (*Conrad*) c
94 Strophonella punctulifera? (*Conrad*)
130 Cyrtolites? expansus *Hall* c

K14d Limestone similar to K14b........................ 3 feet

Delthyris perlamellosa Hall is the only fossil collected here.

K15 Concealed strata. Upper New Scotland.......... 4½ feet

K16 Blue, shaly limestone, very fossiliferous. Upper New Scotland .... 2½ feet

40 Dalmanella subcarinata *Hall* c
47 Leptaena rhomboidalis (*Wilckens*)
52 Meristella laevis (*Vanuxem*) c
82 Spirifer cyclopterus *Hall* c
83 S. macropleura (*Conrad*) c
88 Stropheodonta becki *Hall*
92 Strophonella headleyana *Hall*

K17 Concealed strata which weather as though they were softer than the preceding. Upper New Scotland................ 12 feet

K18 Dense, blue, calcareous shale alternating with more arenaceous beds, the latter specially showing sub-bedding very conspicuously in gray and black laminae. No fossils were found in the beds conspicuous for their sub-bedding. Upper New Scotland.. 15½ feet

33 Coelospira concava *Hall*
39 Dalmanella perelegans *Hall*
40 D. subcarinata *Hall*
47 Leptaena rhomboidalis (*Wilckens*)
71 Rhipidomella oblata *Hall*
76 Rhynchospira formosa (*Hall*) R
79 Schizophoria multistriata? *Hall*
82 Spirifer cyclopterus *Hall* C
88 Stropheodonta becki *Hall*
138 Dalmanites *sp.* r

K19 Strata concealed. Becraft to Port Ewen.......... 73 feet

K20 Dark blue, thinly cleaved, calcareous shale. The upper part is more arenaceous and weathers a dark brown. Fossils are very rare. Port Ewen.................................. 20 feet

33 Coelospira concava *Hall* r
38 Dalmanella concinna *Hall*
88 Stropheodonta becki *Hall*
138 Dalmanites *sp.*
Fish scale?

K21 Concealed strata. Port Ewen.................. 103 feet

K22 Dense, dark blue limestone in beds from 3 to 6 inches thick. Lower Oriskany................................ 12½ feet

25 Beachia suessana? *Hall* R
31 Chonostrophia jervisensis *Schuchert*
40 Dalmanella subcarinata *Hall*
91 Strophonella? conradi? *Hall* r
105 Actinopteria textilis (*Hall*) R
119 Platyceras platystoma *Hall* r

K23 Dark blue, shaly limestone. At the base is the first occurrence of D a l m a n i t e s d e n t a t u s Barrett. Lower Oriskany .... 3 feet

25 Beachia suessana *Hall* r
31 Chonostrophia jervisensis *Schuchert* C
64 Rensselaeria aequiradiata (*Conrad*) R
71 Rhipidomella oblata *Hall* r
134 Dalmanites dentatus *Barrett* r

K24 Dark blue, shaly limestone. Very few fossils. Lower Oriskany .... 3½ feet

31 Chonostrophia jervisensis *Schuchert*
40 Dalmanella subcarinata *Hall* c
65 Rensselaeria ovoides? (*Eaton*) R
126 Tentaculites acula *Hall* r

K25 Dense, blue, arenaceous limestone. Lower Oriskany .... 7 inches

31 Chonostrophia jervisensis *Schuchert* C
61 Orbiculoidea jervisensis (*Barrett*) c

K26 Dark blue, rather heavy bedded, calcareous shale. It is exceedingly fossiliferous where weathered. Lower Oriskany. 1½ feet

31 Chonostrophia jervisensis *Schuchert* C
36 Cyrtina rostrata *Hall* R
40 Dalmanella subcarinata *Hall* c
47 Leptaena rhomboidalis (*Wilckens*) r
66 Rensselaeria subglobosa *Weller* c
71 Rhipidomella oblata *Hall* r
85 Spirifer murchisoni *Castelnau* r
106 Actinopteria textilis arenaria (*Hall*) R
122 Platyceras ventricosum *Conrad* R
126 Tentaculites acula *Hall* c
134 Dalmanites dentatus *Barrett* R

K27 Trilobite bed. Dense blue limestone, containing many trilobite fragments and shells. Lower Oriskany............. 5 inches

31 Chonostrophia jervisensis *Schuchert* C
40 Dalmanella subcarinata *Hall* c
66 Rensselaeria subglobosa *Weller* c
115 Loxonema jerseyense? *Weller*
126 Tentaculites acula *Hall* c
134 Dalmanites dentatus *Barrett* c

This bed is specially noticeable in the hogback northeast of the barn of Mr William Balmos. This is doubtless the locality where Professor Mather and Dr Horton found trilobites so abundantly as to suggest to them the name Trilobite mountain.[1] It is also probably the place from which Dr S. T. Barrett described Dalmanites dentatus.[2] The bed maintains a uniform thickness of 4 to 6 inches wherever seen. It is always bounded above and below by an inch of very arenaceous limestone. The included limestone is almost entirely made up of fossil fragments, specially of Dalmanites dentatus Barrett, Rensselaeria subglobosa Weller and Chonostrophia jervisensis Schuchert. The following fossils were identified in the strata from K25 to K28 inclusive, along the hogback northeast of Mr William Balmos's barn.

21 Vermipora serpuloides *Hall* c
25 Beachia suessana *Hall* c
31 Chonostrophia jervisensis *Schuchert* C
36 Cyrtina rostrata *Hall* R
40 Dalmanella subcarinata *Hall* R
47 Leptaena rhomboidalis (*Wilckens*) R
49 Leptostrophia oriskania *Clarke* R
53 Meristella lata *Hall*
57 Nucleospira elegans *Hall* c
59 Orbiculoidea ampla *Hall* r
66 Rensselaeria subglobosa *Weller* C
71 Rhipidomella oblata *Hall* r
79 Schizophoria multistriata? *Hall* R
82 Spirifer cyclopterus? *Hall* R
85 S. murchisoni *Castelnau* c
Strophomena *sp.*
87 Stenochisma formosa (*Hall*) r
91 Strophonella? conradi? *Hall* r
101 Uncinulus vellicatus *Hall* R
105 Actinopteria textilis (*Hall*) C

[1] Geol. N. Y. 1st Dist. p.333.
[2] Am. Jour. Sci. 1876. 2:200.

112 Diaphorostoma nearpassi (*Weller*) R
113 D. ventricosum (*Conrad*) R
115 Loxonema jerseyense *Weller* c
123 Platyceras *sp.* R
126 Tentaculites acula *Hall* r
127 T. elongatus *Hall* r
134 Dalmanites dentatus *Barrett* C
139 Homolonotus vanuxemi *Hall* c

K28 Dark gray, calcareous sandstone containing very few fossils. Lower Oriskany.................................. 2 feet

K29 Concealed strata. Lower Oriskany to Upper Oriskany.................................. 66 feet

K30 Upper Oriskany.............................. 3½ feet

K30a Dark blue, rather heavy bedded, silicious limestone. 6 inches

K30b Concealed strata.......................... 1½ feet

K30c Dark blue, rather heavy bedded, silicious limestone, very full of specimens of Orbiculoidea jervisensis (Barrett) .... 1½ feet

The following fossils were identified from this.

25 Beachia suessana *Hall* R
48 Leptocoelia flabellites (*Conrad*) r
61 Orbiculoidea jervisensis (*Barrett*) C
85 Spirifer murchisoni *Castelnau*
120 Platyceras reflexum? *Hall* R
125 Conularia pyramidalis jervisensis *Shimer* r

K31 Strata concealed. Upper Oriskany............... 50 feet

K32 Very dense, blue limestone from which were identified Megalanteris ovalis? Hall, Spirifer cyclopterus Hall and S. murchisoni Castelnau. Upper Oriskany.................................... 21 inches

K33 Same as preceding but more shaly in beds of from 1 to 4 inches in thickness. One foot from the top and scattered through a half foot bed is the lowest chert noticed in the Upper Oriskany. There are very few fossils here. Upper Oriskany.......... 6 feet

K34 Dense blue limestone terminating in a 6 inch ledge which has finely disseminated chert in the middle and closes with an inch which is practically composed of fossils. Upper Oriskany........ 7 feet

31 Chonostrophia jervisensis *Schuchert*
34 Coelospira dichotoma *Hall*
40 Dalmanella subcarinata *Hall*
48 Leptocoelia flabellites (*Conrad*)
53 Meristella lata *Hall*
85 Spirifer murchisoni *Castelnau* C
113 Diaphorostoma ventricosum (*Conrad*)
127 Tentaculites elongatus *Hall*

K35 Dense blue limestone with two small chert bands, each in the lower portion of a very fossiliferous layer. The fossils are almost wholly specimens of Spirifer murchisoni Castelnau. Upper Oriskany.............................. 3½ feet

K36 Strata concealed. Upper Oriskany................ 8 feet

K37 Dense, blue limestone. Upper Oriskany.......... 2½ feet

K38 Dense blue limestone, exceedingly fossiliferous. Upper Oriskany .... 6 inches

53 Meristella lata *Hall* r
80 Spirifer arenosus? (*Conrad*) R
85 S. murchisoni *Castelnau* C
113 Diaphorostoma ventricosum (*Conrad*)

K39 Very fossiliferous, dense, blue limestone. Upper Oriskany .... 18 inches

48 Leptocoelia flabellites (*Conrad*) c
53 Meristella lata *Hall* C
68 Reticularia modesta (*Hall*) r
88 Stropheodonta becki *Hall* r
127 Tentaculites elongatus *Hall* r
Phacops *sp.* R

K40 Blue limestone. The middle and upper parts are specially fossiliferous. Tentaculites elongatus Hall is by far the most noticeable fossil here. Upper Oriskany.............. 2 feet

53 Meristella lata *Hall* C
85 Spirifer murchisoni *Castelnau* C
111 Diaphorostoma desmatum *Clarke* r
127 Tentaculites elongatus *Hall* C
Phacops *sp.* R

K41 Esopus strata including the portion covered by the swamp between the Oriskany and the Esopus.................. 550 feet

The gross structure of the Esopus is shown in figure 7.

K42 A dark arenaceous shale, cleaving into slate pencillike pieces. Fossils, owing to the great development of cleavage, are exceedingly rare. The only species identified was Coelospira acutiplicata (Conrad), several specimens of which were found. This fossil-bearing horizon represents merely an inch or two of rock on the uppermost surface of the Esopus; for when followed southeastward, not a single fossil could be found though prolonged search was made for that purpose. Onondaga......... 1-2 inches

K43 The 29 feet of strata which are concealed beneath the Erie Railroad here outcrop almost a quarter of a mile to the southwest along the eastern side of the railroad tracks. The only fossil identi-

fied was Coelospira acutiplicata (Conrad). It was found in very large numbers but all were more or less distorted from the very great development of cleavage. Onondaga...... 29 feet

K44 On the northwestern side of the Erie tracks at this section is an excellent exposure of very dark gray, calcareous shale, weathering light gray. It is very fossiliferous, many of the fossils being pyritized, specially the gastropods. This cleaves into much larger and broader pieces than in the two preceding localities. The cleavage here as in all the Esopus strata is so perfect and continuous that it closely resembles bedding. At this locality the bedding is seen in the dark colored ribbons about 6 inches in width passing across the cleavage surface. In this respect it closely resembles the Pennsylvania roofing slate except that the latter has, as a rule, narrower ribbons. Onondaga......................... 18 feet

The following fossils were identified:

Zaphrentis? r
27 Chonetes hemisphericus? *Hall* r
29 C. yandellanus *Hall* R
32 Coelospira acutiplicata (*Conrad*) C
35 C. grabaui *Shimer* C
40 Dalmanella subcarinata? *Hall* c
42 Eatonia medialis (*Vanuxem*) r
116 Loxonema *sp.* c

K45 These strata are very shaly, breaking into broad, thin plates. Slickensides were developed along the cleavage in places. At the top of the hill the strata become more calcareous; thin beds of impure limestone occur at intervals. Several specimens of Atrypa reticularis (Linn.) were found. Onondaga 100 feet

K46 Concealed strata. Onondaga................... 12 feet

K47 The strata concealed by the old public road leading to the residence of Mr Henry Hoffman, are found further southward. The cleavage gradually becomes coarser, more platy and with the dark gray, shaly limestone occur intermittent beds of a dense, blue limestone which is at times quite fossiliferous but is usually apparently destitute of fossils. Onondaga................ 20 feet

23 Atrypa reticularis (*Linn.*) C
27 Chonetes hemisphericus *Hall* c
32 Coelospira acutiplicata (*Conrad*) R
47 Leptaena rhomboidalis (*Wilckens*) r
55 Meristella *sp.* R
67 Reticularia fimbriata (*Conrad*) r
84 Spirifer macrus *Hall* c
133 Dalmanites *cf.* anchiops (*Green*) R
Phacops rana (*Green*) r

K48 Mostly concealed strata but of lithic characters similar to the preceding. Onondaga.............................. 24 feet

K49 Strata rather shaly, mostly concealed. Onondaga... 15 feet

K50 A rather heavy bedded gray limestone. One layer near the middle is quite fossiliferous. This outcrops along the Newburg turnpike, opposite the barn of Mr Ludwig Laux; the outcrop is very noticeable from the great abundance of Atrypa reticularis (Linn.). Onondaga.................................. 10 feet

4 Ceratopora *sp.* R
8 Favosites *sp.* R
23 Atrypa reticularis (*Linn.*) C
33 Coelospira concava (*Hall*) R
Phacops rana (*Green*) r

K51 Cherty, exceedingly closely grained limestone, in beds 3 to 6 inches thick. The chert is most abundant in 2 to 6 inch bands parallel to the bedding but is found also scattered irregularly throughout all the beds. The chert does not occupy a bed to the exclusion of the limestone, as is usually the case in the New Scotland and Oriskany, but occurs in very irregular masses through it; this gives the rock when weathered an exceedingly rough appearance and at times it is pitted and amygdaloidal like. This rock is exposed for only about 600 feet along the Newburg turnpike, on the northeast side of the road, and rises in places almost on the dip to a hight of 30 to 50 feet. Onondaga...................... 7 feet

Section L

Section L begins at the foot of an old limestone quarry[1] about 150 rods northeast of section K.

L1 Strata covered from the marsh to the first rock outcrop at the base of an old quarry. Lower New Scotland and Upper New Scotland.. 170 feet

L2 A dense, finely grained, bluish gray limestone. The lower and upper layers are quite shaly and show light and dark laminae. No chert was noticed. Fossils were abundant, in certain beds. As is usually the case, few or no fossils were found in the beds showing the light and dark laminae, except in the very lowest band. Upper New Scotland................................ 5 feet

[1]This is doubtless the Upper Quarry of Barrett from which he gave the name "Upper Quarry stone" to the Becraft. Am. Jour. Sci. 3, 13:386.

5 Enterolasma strictum *Hall* r
21 Vermipora serpuloides *Hall* r
33 Coelospira concava *Hall* c
40 Dalmanella subcarinata *Hall* C
47 Leptaena rhomboidalis (*Wilckens*) c
55 Meristella *sp.* r
71 Rhipidomella oblata *Hall* r
82 Spirifer cyclopterus *Hall* C
88 Stropheodonta becki *Hall* c
94 Strophonella punctulifera (*Conrad*) r
137 Dalmanites *sp.*
140 Phacops *cf.* logani *Hall* r

L3 Upper New Scotland........................ 8⅔ feet

Subdivided as follows:

L3a Dark blue limestone in beds from 3 to 6 inches thick with considerable chert in the lower beds.................... 3½ feet

L3b Very cherty, bluish gray limestone.............. 1 foot

L3c Coarsely grained to very finely grained limestone usually in a single bed. Chert is developed in its lower portion. At times there are mere pockets of the coarsely grained scattered at intervals through the finely grained. This is very fossiliferous..... 2½ feet

L3d A dark bluish gray limestone alternating with half inch bands of an arenaceous limestone, the latter showing light and dark laminae and few or no fossils........................ 20 inches

The following is a list of fossils identified from L3. The fossils from the different beds were not kept separate.

5 Enterolasma strictum *Hall* r
12 Lichenalia torta *Hall* c
31 Chonostrophia jervisensis *Schuchert* R
40 Dalmanella subcarinata *Hall* r
41 Delthyris perlamellosa *Hall* c
47 Leptaena rhomboidalis (*Wilckens*) c
52 Meristella laevis (*Vanuxem*) r
55 M. *sp.* c
82 Spirifer cyclopterus *Hall* c
88 Stropheodonta becki *Hall* c
95 Trematospira multistriata *Hall* R
97 Uncinulus campbellanus (*Hall*) R
101 U. vellicatus *Hall* R
127 Tentaculites elongatus? *Hall* R

L4 Coarsely grained, gray limestone, usually in one bed. Very fossiliferous. Becraft............................. 2½ feet

5 Enterolasma strictum *Hall* r
11 Edriocrinus pocilliformis *Hall* c
12 Lichenalia torta *Hall* r
23 Atrypa reticularis (*Linn.*) r
46 Gypidula pseudogaleata (*Hall*) C
47 Leptaena rhomboidalis (*Wilckens*) C
52 Meristella laevis (*Vanuxem*) C
54 M. princeps *Hall* r
81 Spirifer concinnus *Hall* c
82 S. cyclopterus *Hall* r
92 Strophonella headleyana? *Hall* R

L5 Becraft............................... 5 feet, 9 inches

L5a Rather finely grained, dark gray limestone. The basal foot

in places is coarse and resembles the preceding. It is very hard and contains few fossils. Edriocrinus pocilliformis Hall r and Leptaena rhomboidalis (Wilckens) were the only species identified .... 3 feet

L5b Shaly, rather friable, finely grained limestone. Exceedingly fossiliferous .... 9 inches

From here the following fossils were obtained:

5 Enterolasma strictum *Hall* r
11 Edriocrinus pocilliformis *Hall* C
Dalmanella *sp.*
41 Delthyris perlamellosa? *Hall* R
47 Leptaena rhomboidalis (*Wilckens*) r
57 Nucleospira elegans *Hall* c
62 Orthothetes woolworthanus *Hall* R
81 Spirifer concinnus *Hall* C
94 Strophonella punctulifera (*Conrad*) R

Spirifer concinnus is in places so abundant that it makes up almost the entire rock mass.

L5c Limestone similar to L5a, usually in one bed. It is very hard and contains few fossils. The only species identified were Edriocrinus sacculus Hall r and Leptaena rhomboidalis (Wilckens) c .... 2 feet

L6 Finely grained, bluish gray limestone. At the base and in the middle are 4 inch friable, shaly bands similar to L5b and as we would expect, since the fossils are fairly abundant throughout the entire bed, many forms are similar to those in L5b, yet there is a great decrease in the abundance of Spirifer concinnus and an entire absence of Nucleospira elegans and Edriocrinus pocilliformis which were abundant in the lower bed. This is placed in the Becraft on account of the abundance of Spirifer concinnus. The other abundant fossils also are those which were specially noticeable in the Gypidula pseudogaleata beds .... 8 feet

5 Enterolasma strictum *Hall* r
23 Atrypa reticularis (*Linn.*) c
40 Dalmanella subcarinata *Hall* r
41 Delthyris perlamellosa *Hall* R
47 Leptaena rhomboidalis (*Wilckens*) c
52 Meristella laevis (*Vanuxem*) R
79 Schizophoria multistriata *Hall* R
81 Spirifer concinnus *Hall* c
82 S. cyclopterus *Hall* R
88 Stropheodonta becki *Hall* r
94 Strophonella punctulifera (*Conrad*) R
97 Uncinulus campbellanus? (*Hall*) R

L7 A bluish gray, arenaceous limestone showing darker and lighter laminae very plainly, specially in the upper portion. The lower is exceedingly fossiliferous and there the following fossils were found. Port Ewen............................ 1 foot

33 Coelospira concava *Hall* C	85 Spirifer murchisoni *Castelnau* c[1]
40 Dalmanella subcarinata *Hall* r	88 Stropheodonta becki *Hall* r
43 Eatonia singularis (*Vanuxem*) c	109 Cypricardinia lamellosa *Hall* R
50 Lingula *sp.* R	

L8 Concealed strata. Port Ewen to Lower Oriskany... 178 feet

L9 Finely grained, gray, argillaceous limestone. There is an alternation of more calcareous with more arenaceous beds. As followed southwest on the strike, it led almost directly below the trilobite bed. Chonostrophia jervisensis Schuchert is the only fossil found here. Lower Oriskany................ 14 feet

L10 Concealed strata. Lower Oriskany and Upper Oriskany .... 120 feet

L11 Strata concealed except 3 feet from the top, a 1 foot outcrop containing a band of black unfossiliferous chert, very similar to K33. Upper Oriskany.............................. 10 feet

L12 Strata concealed with the exception of the uppermost bed which is exposed on the dip for 15 vertical feet. This contains many specimens of Spirifer murchisoni Castelnau, Diaphorostoma ventricosum (Conrad) and Tentaculites elongatus Hall. Upper Oriskany .... 14 feet

L13 Strata concealed except the uppermost which is exposed on the dip for about 40 vertical feet. Here were found one specimen of Lingula perlata? Hall and very many of Leptocoelia flabellites (Conrad) but no specimens of Tentaculites were found. Upper Oriskany..................... 17 feet

L14 Strata concealed by the marsh. Upper Oriskany to Esopus .... 70 feet

L15 Esopus strata between the marsh and the Newburg turnpike .... 540± feet

[1] *See* note 1, p.251.

Discussion of individual species

HYDROZOA

Stromatopora concentrica? Goldfuss

The organism referred to this species is very abundant in the Favosites bed.

ACTINOZOA

Blothrophyllum promissum? Hall

Several specimens of a coral very similar to this species were noticed in the Onondaga formation along the Newburg turnpike. It was impossible to get any free from the matrix, but the sections which could be observed had all the appearances of this species.

Enterolasma (Streptelasma) strictum (Hall)

This simple coral is very abundant and always well preserved, specially in the Coeymans and New Scotland. It is found less abundantly in the Becraft and Port Ewen. A specimen of average size measures about 15mm in length by 6mm in width at the large end.

Zaphrentis roemeri Edwards & Haime

A specimen from the Favosites bed has a greatest diameter of 38mm. It has about 80 septa, most of those in the section reaching over half way to the center. There are a few shorter ones but no regular alternation of longer and shorter ones was observable. No entire specimens were procured so that the length is not known. This was observed only in the Favosites bed where it was quite abundant.

Favosites helderbergiae Hall

The very common coral of the lowest Coeymans, where it occurs in great abundance. It is found rarely in the upper Manlius. The fact that it is present in the greatest abundance in the coarsely crystalline beds seems to indicate that it is a reef species. A specimen from the base of the Coeymans shows as greatest diameter of corallites 1.5mm, the average width being 1.3mm. One section gave 10 tabulae in 7.5mm, another 12 in 9.5mm, averaging 1 tabula to 1mm. A specimen from

the middle Coeymans gave as greatest diameter of the corallites 1.25mm, the average width was 1mm. It gave in one section 12 tabulae in 10mm; in another 18 in 15mm, averaging 1½ to 1mm. The wall in both specimens is always twice as thick as the tabulae. The majority of tabulae on the Coeymans specimen are very regularly concave with a concavity of from one third to one fifth the diameter of the corallite. The specimen from the Favosites bed shows most of the tabulae flat with only a few concave. A few tabulae on both specimens are placed obliquely to the walls. There were faint indications in both specimens when placed in weak acid for a short time of from one to two rows of pores on the sides of the cells, usually located about halfway between the tabulae.

Comparison of Favosites niagarensis and F. helderbergiae

	F. niagarensis	F. helderbergiae[1]
Average width of cells	1.3mm	1.5mm
Usual number of tabulae in 10mm...........	7–9	12
Extreme number of tabulae in 10mm.......	4, 10–12	10, 15
Corallum.............	Lenticular or hemispheric	Spheric

Professor Hall says[2] that "F. helderbergiae differs from F. niagarensis (which it resembles in the size of its cells) in having more numerous diaphragms and in the mural pores being on the lateral faces instead of at the angle of the cells." His figures of F. niagarensis, however,[3] show the pores on the lateral faces of the cells and not at the angles. This would leave no difference between the two species except the number of tabulae. The cells of a specimen in the Columbia University collection from the Niagara limestone, locality not given, average about 1.3mm in diameter; it has from 13 to 16 tabulae in 10mm, while the one to two rows of

[1]Measurement taken from Hall's figures, Pal. N. Y. 2:125, pl.34a (bis), fig.4a-i.

[2]Pal. N. Y. 6:8.

[3]Pal. N. Y. v.2, pl.34a.

mural pores are on the lateral faces of the cells and about midway between the tabulae. The tabulae are thus as numerous as in F. helderbergiae. The corallum is lenticular in shape, and accordingly the only difference between the two species is in the shape of the corallum.[1] It was only in the Favosites bed that the shape of the corallum was observable and this only in cross section. Here the corallum usually gives, at right angles to the bedding plane, a round or elongate cross section with the corallites growing in all directions from a central point. A few, however, were noticed which had a semicircular cross section with the flat portion lying on the bedding plane and the corallites growing from the center of the flat portion. It seems, then, that we have the lenticular, the hemispheric, as well as the spheric shaped corallums in this 3 foot Favosites bed.

It seems to be a question worth considering whether two distinct species should be based wholly on the form of the colonies of which the individuals are exactly alike. Might not the shape of the colonies be determined by the varying conditions of growth?[2, 3]

Favosites sphaericus Hall

Found from the Upper Manlius to the Lower New Scotland inclusive, being specially abundant in the Favosites bed. One specimen from the Coeymans measured 12mm in length by 10mm in width; the tubes averaged a diameter of .3mm with a few as wide as .5mm. The angles of the walls were quite nodose. On one specimen from the Upper Manlius the tubes averaged about .2mm in diameter, while the corallum was 5mm long by 3mm wide at the

[1]After this determination was made, it was found that Lambe had reached a similar conclusion four years previously.

Contrib. Can. Pal. v.4, pt 1, 1899, p.7.

[2]F. niagarensis was established by Hall in 1852. Pal. N. Y. 2:125. F. helderbergiae was established by Hall in 1874. N. Y. State Mus. Nat. Hist. 26th Rep't. p.111.

[3]Girty concludes from a study of F. helderbergiae and F. conicus Hall from the Helderberg of Albany county, N. Y., that both may refer to the same organism at different stages of growth and preservation. Girty, G. H. A Revision of the Sponges and Coelenterates of the Lower Helderberg Group of New York. N. Y. State Mus. 48th An. Rep't. 1894. pt 2.

widest portion. One specimen from the Favosites bed was noticed incrusting a mass of Stromatopora and being in turn incrusted by it. Very small specimens of what appear to be this species are quite abundant in some of the Upper Manlius beds; but owing to the great density of the rock, only pieces too fragmentary to be identified were acquired.

PELMATOZOA

Edriocrinus pocilliformis Hall

Very abundant in the Becraft where alone it occurs. Only the bases of this crinoid have been found preserved and the radial plates could not be made out on them. Those from the shaly limestone are, as a rule, smaller than those from the heavier beds. The former average 6mm in the diameter of the summit of the base and 7mm in length; the latter average 8mm by 10mm. The larger species, E. sacculus Hall, was not noticed in the higher Oriskany beds.

BRYOZOA

Lichenalia torta Hall

Very abundant, but the celluliferous tissue has usually been removed, leaving only the surface of the epitheca. It was found quite abundantly in the whole of the Helderbergian with the possible exception of the New Scotland. It also occurs in the Favosites bed.

Lioclema cellulosum (Hall)

Very abundant in the Coeymans and quite well preserved on the weathered surfaces of the beds.

L. ponderosum (Hall)

This bryozoan was found only in the lower New Scotland and there not abundantly.

Monotrypa tabulata Hall

An elongated, spheroidal corallum of this species from the Lower New Scotland has an average of 20 corrugations on the outer surface of the cell tubes in 5mm, with a diameter for the cell tubes of about .4mm.

Monotrypella? abrupta (Hall)

One specimen from the Lower New Scotland averages about 10 septa in 1mm beyond the abrupt outward turning of the tubes.

Another specimen from the Lower Oriskany, identified provisionally with this species, appears to have as many septa before the abrupt outward bending of the tubes as after it. In this respect it differs from the type description.[1]

Orthopora regularis (Hall)

This small species does not appear to be quite so abundant as the following one and was found at the same horizon.

O. rhombifera (Hall)

Exceedingly abundant and well preserved in the Coeymans and Lower New Scotland.

Unitrypa nervia (Hall)

The most abundant fenestelloid bryozoan in the Coeymans; it does not differ from the type description.

U. praecursa (Hall)

Abundant in the Coeymans; it may be a distinct variety since the margins of the expanded summits of the carinae have simply a row of nodes; in no instance was there any lengthening of these nodes noticed so as to form slender bars connecting them with the contiguous carinae as noticed by Professor Hall.[2]

Vermipora serpuloides Hall

In one specimen from the Upper New Scotland the tubes have a diameter of from less than .5mm to .75mm, somewhat less than Professor Hall's description of the type specimen. The tubes are covered with close, prominent, concentric wrinkles. No longitudinal striae were noticed. It is quite abundant in the Lower New Scotland and much less abundant in the Upper New Scotland.

BRACHIOPODA

LINGULA

Many specimens of Lingula and Orbiculoidea occur in phosphatic nodules in the New Scotland beds. Usually the shell is too crushed

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[1] Pal. N. Y. 6:13, pl.9.
[2] Pal. N. Y. 6:54, pl.21, fig.14-18.

for identification. Professor Hall[1] calls attention to these peculiar coproliticlike nodules in the rocks of this formation in Albany county, N. Y. Our specimens agree with his in that they are "uniformly elongate or oval in form."

Orbiculoidea ampla Hall

Rare in the lower Oriskany where alone it was found.

O. jervisensis (Barrett)

The most characteristic shell of the middle Oriskany. It occurs rather less abundantly in the Lower Oriskany. A noticeable feature of this species is that it frequently lies at right angles to the bedding plane.

Pholidops ovata Hall

This little shell is quite abundant on the weathered rock surfaces of the Upper Coeymans. It is also present in the Lower New Scotland. A specimen of average size measures 3.5mm by 3mm.

Leptostrophia oriskania Clarke

Only one specimen was found and that in the Lower Oriskany. It is smaller than the average given by Clarke[2] having a length of but 12mm and a width of 14mm. The irregular, concentric wrinkles can be plainly seen.

Leptaena rhomboidalis (Wilckens)

Abundant in the whole of the Helderbergian and Lower Oriskany. The characters of the shell are very constant and hold true to the type. It is specially abundant in the New Scotland and Becraft.

Stropheodonta becki Hall

Quite abundant in the whole of the Helderbergian, occurring also in the Upper Oriskanian. It holds quite true to the type description.

S. varistriata (Conrad)

Very abundant in the Lower and Upper Manlius, it is also present in the Favosites bed and Coeymans. The Coeymans species differs

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[1] Pal. N. Y. 1859. 3:158.

[2] N. Y. State Mus. Mem.3, p.53, pl.7, fig.29-35.

somewhat from that of the Manlius. In the Manlius the striae are strong and usually subequidistant, with from one to several finer striae between them. A pedicle valve measuring 19 by 27mm showed very little difference in the strength of the striae but a brachial valve of about the same size showed it very distinctly, but even here not so prominently as on the smaller shells. The Coeymans shells are a little more convex. The coarse striae are less pronounced, while the finer ones, which vary in number from four to a dozen or more, are filiform.

S. varistriata var. **arata** Hall

Shell very convex with its body covered with angular, coarse striae; the sides of these as well as the concave area between them are covered with about six filiform, rather undulate striations. The umbonal region and the somewhat flattened area at the cardinal angle show its derivation from the typical Manlius S. varistriata, for here the striae are less irregular and the intermediate area is flattened. It was found not very abundantly in the Coeymans and New Scotland.

Strophonella? conradi Hall

The specimens identified with this species are from the Lower Oriskany. The best preserved one measures 35mm by 40mm. The one figured by Hall[1] is somewhat smaller, about 29mm by 37mm. The shell is uniformly convex, the greatest convexity being at the middle. It is more coarsely striated than Orthothetes woolworthanus, the striae being fine and sharp. These striae on exfoliation become rounded while the depressions between them are pitted. On another specimen of the same dimensions and similar striae, the exfoliated striae themselves are very distinctly punctate. No denticulations were noticed on the cardinal area which is poorly preserved.

S. headleyana Hall

Only molds of this species were found and these were usually fragmentary. The pedicle valve is distinctly convex at the umbo, with a long, broad and rather shallow concavity toward the front.

[1]Pal. N. Y. v.3, pl.16, fig.13-15.

The external molds of the striae are crenulate. It was found in the Lower and Upper New Scotland and probably in the Becraft.

S. leavenworthana Hall

A single specimen was found and this in the lower part of the Port Ewen. This is strongly geniculate toward the front of the shell, while the posterior portion, after a slight depression at the geniculation rises but little over low concentric wrinkles to the umbo.

S. punctulifera (Conrad)

Usually occurs only as external and internal molds. The brachial valve of this species is deeply concave at the umbo but becomes strongly geniculate toward the front. The puncta are usually poorly preserved. It occurs, but in moderate abundance, in the Coeymans, Upper New Scotland and Port Ewen; one specimen represents it in the Becraft.

Orthothetes woolworthanus Hall

Hall describes the surface of this as being covered with fine, rounded striae.[1] It is a rare species and is represented in our collection by several specimens from the New Scotland and Becraft. One well preserved brachial valve, measuring 28mm by 34mm, is flattened in the region of the umbo but becomes quite convex toward the front. The surface is covered with numerous, very fine, rounded, radiating striae.

Orthis sp.

In the Lower Oriskany several specimens of a large Orthis were found but they were all too poorly preserved for identification; they much resembled R h i p i d o m e l l a m u s c u l o s a (Hall).

Chonetes hemisphericus Hall

Quite abundant in the Onondaga. The specimens agree very closely in average size, convexity and striae with those described by Hall.[2]

C. hudsonicus Clarke

Several specimens from the Lower New Scotland are referred to this species. One of medium size measures 9mm by 15mm by

[1] Weller speaks of the striae in the New Jersey specimens as angular. Geol. Sur. N. J. Paleontology. 3:278.

[2] Pal. N. Y. 4:118, pl.20, fig.6a-d.

1.5mm in length, breadth and thickness. The largest measures 12mm by 23mm by 3mm. No spines are noted. The surface is very finely striated.

C. yandellanus Hall

A pedicle valve about 7mm by 12mm in length and breadth, from the lower Onondaga was identified with this species. The cardinal angles are very distinctly flattened. There are about 50 strong, rounded, radiating striae which are as strongly developed on the flattened area of the valve at the cardinal angle as on the rest of the shell.

Chonostrophia jervisensis Schuchert

The resupinate character is well preserved in all the specimens. The striae are narrow with broad, rather flat interspaces where specially the very numerous and fine concentric markings are noticeable under a glass. A pedicle and a brachial valve of average size each measured 7mm by 12mm in length and breadth. This is one of the most abundant brachiopods of the Lower Oriskany. It is found more rarely in the Upper Oriskany, while one specimen only represents it from the Upper New Scotland.

Dalmanella concinna Hall

Represented in the Port Ewen beds by rather small specimens; they average 7mm by 6mm. They are often found as internal molds and one valve is preserved as frequently as the other.

D. perelegans Hall

Quite abundant and well preserved in the Coeymans and Upper New Scotland.

D. subcarinata Hall

Abundant, specially in the Coeymans, New Scotland and Lower Oriskany, but is also well represented in the Becraft, Port Ewen, Upper Oriskany and possibly in the Lower Onondaga. It is thus seen that this very persistent species thrived equally well in clear and muddy waters. Specimens of a Dalmanella similar to this species except in size are quite abundant in the Lower Onondaga. The largest form observed measured 10.5mm by 13mm in length and breadth.

Rhipidomella assimilis Hall

The single specimen from the Lower New Scotland identified with this species is the internal mold of the brachial valve; the front of the mold is destroyed. The anterior part of the flabellate muscular scar is quite high.

R. eminens Hall

There are several specimens from the Upper New Scotland in the collection which agree very closely with this species. Two are young individuals and show very prominently the alternation of stronger and finer striae.

R. oblata Hall

Shell well preserved and holds quite true to the type. It averages in size 28mm by 34mm by 11mm in length, breadth and thickness. It is never an abundant species but is found in the Coeymans, New Scotland and Lower Oriskany.

R. tubulistriata Hall

A single valve from the Upper New Scotland. It shows the characteristic fasciculation of the striae with the porelike openings on them.

Gypidula angulata Weller

One partial pedicle valve from the Coeymans answers to the description of this species,[1] with the exception that it has three plications on the lateral slopes of the shell instead of but one; the one next the fold is subangular and the most prominent, the other two are faint and broadly rounded.

G. galeata (Dalman)

Exceedingly common and well preserved in the Coeymans where it occurs from the base to the summit. It appears suddenly and in great numbers directly on the Favosites bed. A few specimens have prominent and even plications and lack sinus and fold; in these respects they agree with the varietal differences pointed out by Weller.[2]

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[1]Weller. Geol. Sur. N. J. 3:280, pl.28, fig.13–21.

[2]——— Geol. Sur. N. J. 3:280.

G. pseudogaleata (Hall)

Very abundant in the 2½ feet of the lowest Becraft and is of the average size of those figured by Hall.[1]

Stenoschisma formosa Hall

A single specimen was found in the Upper New Scotland and several in the Lower Oriskany.

Uncinulus campbellanus (Hall)

Occurs very rarely both in the Upper New Scotland and Becraft. At Becraft mountain, N. Y., it is very abundant in the latter formation.

U. nucleolatus Hall

Very abundant in the Lower Coeymans. In size as well as in number and shape of plications it is normal.

U. pyramidatus Hall

Not found outside the Coeymans. This with the preceding species is specially characteristic of the lower portion of the Coeymans proper.

Eatonia medialis (Vanuxem)

An abundant species, found both as perfect shells and as internal molds of the pedicle valve. It is most abundant in the New Scotland but also occurs in the Coeymans and Lower Onondaga. In the Lower Onondaga were found two internal molds of the pedicle valve, 16mm wide, but they have the characteristic muscular impressions.

E. singularis (Vanuxem)

Not nearly so abundant as the preceding but is usually well preserved and occurs frequently in the Lower New Scotland and Port Ewen and very rarely in the Upper New Scotland.

Beachia suessana Hall

Usually well preserved and quite abundant in the Lower Oriskany. One specimen was also noticed in the Upper Oriskany.

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[1]Pal. N. Y. v.3, pl.48, fig.2a-h.

Rensselaeria aequiradiata (Conrad)

One specimen is 25mm long and 15mm wide at the widest place which is anterior to the middle of the shell. The greatest thickness, 11mm, is posterior to the middle. Another one from the Lower Oriskany measures 23+mm by 15mm, the complete length could not be determined owing to the broken condition of the front of the shell.

R. subglobosa Weller

This shell was called by Dr S. T. Barrett,[1] on the identification of Professor Hall, Rensselaeria mutabilis Hall. But Dr Barrett explains that it is much larger than any known before. It differs from this, however, also in its surface markings and was hence made into a new species by Dr Weller.[2] This is one of the most abundant shells of the Trilobite bed, and is nearly always well preserved.

Megalanteris ovalis? Hall

Two specimens were provisionally identified with this species; both are internal molds of the pedicle valve and agree very closely with the figures and description given by Hall.[3]

Atrypa reticularis (Linnaeus)

Found only in the Coeymans, Becraft and Onondaga, the purely calcareous formations; it is quite abundant in each of these.

Atrypina imbricata Hall

Quite abundant in the Upper New Scotland but no specimen was noticed in the Lower New Scotland. A large shell measured 9mm by 9.5mm by 4.5mm in length, breadth and thickness respectively.

Spirifer vanuxemi Hall

One of the most abundant and constant shells in the Manlius. The usual size of the brachial valve is 5mm by 8mm by 2mm in length,

[1]Notes on the Lower Helderberg Rocks of Port Jervis, N. Y. Lyc. Nat. Hist. Ann. 1876. 11:290.

[2]Geol. Sur. N. J. 3:329, pl.42, fig.11-18.

[3]Rensselaeria ovalis Hall. Pal. N. Y. 1859. 3:458, pl.106, fig.2a-l.

width and concavity respectively; that of the pedicle valve is 7mm by 9mm by 3mm.

This species is very similar to S. crispus of the Niagara group as shown by a comparison of Hall's figures and the following measurements:

Length	Breadth	Proportion of length to breadth	Number of plications on each side of sinus		
S. vanuxemi from Trilobite mountain, N. Y.					
6	8	1.34	2	Brachial valve	Average size
7	10	1.43	3	Pedicle valve	
10	12	1.2	5	Pedicle valve very convex	
S. crispus, Niagara shale, Waldron Ind.[1]					
12	15	1.21	4	Pedicle valve	
11	15	1.36	3	Brachial valve	
S. crispus from Rochester shale, Niagara gorge, N. Y.[1]					
5.5	9	1.64	3	Pedicle valve	Shells of this size are very abundant
4.5	9	2	2	Brachial valve	

As seen from the above comparisons and figures,[2,3] S. vanuxemi bears a closer resemblance to S. crispus of Waldron than it does to the Niagara gorge species. This similarity is specially noticed in the proportion of length to breadth and in the number of plications. The Waldron shells are also much more gibbous and thus approach S. vanuxemi more nearly than do the Niagara gorge specimens. But the cardinal area is much higher even in the young of all specimens of S. crispus examined than in any of S. vanuxemi. It is thus seen that while S. vanuxemi is apparently much more closely related to the western S. crispus than it is to the eastern, that its possible derivation from the western species could not have been a direct one.

[1]These measurements are from specimens in the paleontologic collections of Columbia University, New York.

[2]S. crispus. Pal. N. Y. 2:262, pl.54, fig.3a-k.

[3]S. vanuxemi. Pal. N. Y. 3:198, pl.8, fig.17-23.

But this close similarity may be due to a possible derivation of both from S. petilus of the Waldron area.[1, 2]

S. cyclopterus Hall

The young of this species is quite similar to S. vanuxemi in external form and markings. A young specimen of S. cyclopterus from the Coeymans gives the following measurements:

Length	Breadth	Proportion of length to breadth	Number of plications on each side of sinus	
2.5	4.5	1.8	3	Brachial valve
5	9	1.8	4	Pedicle valve

In the above brachial valve, the central plication or fold is very slightly larger than those on each side of it; and the plications are but slightly wider than the furrows between them. No flattening of the fold was noticeable. The sinus of the pedicle valve near the umbo is but slightly wider than the furrows on each side, while at the front of the shell it is about twice as wide. All this is also true of S. vanuxemi. This young specimen also agrees with S. vanuxemi in the number of plications but exceeds it in the proportion of length to breadth of the valves. With the exception of this last fact, the similarity between the two species is almost perfect and suggests a possible derivation.[3]

In many of the New Scotland beds occur frequently only the internal molds of S. cyclopterus. They bear a general resemblance to S. murchisoni but the cast of the musculature of the pedicle valve of the former is narrower and the sinus in it is not as wide as in the latter species. The internal mold of the plications is also usually less pronounced in the former. The surface of the mold on both sides of the muscular impression is papillose in both species, indicating a punctate surface on the corresponding parts of the shell.

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[1] Grabau. N. Y. State Pal. An. Rep't 1902, p.1046.

[2] Clarke & Beecher. N. Y. State Mus. Mem. 1. 1889. p.75.

[3] Stuart Weller [Geol. Sur. N. J. 3:287] calls attention to the likelihood of the derivation of S. cyclopterus from S. vanuxemi.

S. cyclopterus occurs very abundantly in the Coeymans and Upper New Scotland; it is found less frequently in the Lower New Scotland and Becraft. The Coeymans specimens are more compressed laterally than the majority of those from the New Scotland. The latter ones have the plications more angular also, thus partially approaching S. murchisoni.

S. concinnus Hall

Exceedingly abundant in the Becraft. It differs somewhat from the type description.[1] The number of plications on a shell of average size is less than that given by Hall. The following table will give an idea of the comparison in the pedicle valve between Hall's figures, specimens measured from Becraft mountain, New York, from Schoharie, New York and from Trilobite mountain.

Length	Width	Number of plications	
Hall's figures			
25	34	12	From the New Scotland, called by Hall a large shell.
21	22	14	From the Becraft. This Hall calls large.
12	13	8	From the Becraft.
10	13	6	From the Becraft.
Specimens from Becraft mountain			
21	24	9, 10	A large specimen.
13	18	8	
15	22	9	The average size
Specimens from Schoharie, New York			
27	31	13	Probably from the New Scotland.
28	29	11	Probably from the New Scotland.
Specimens from Trilobite mountain, New York			
25	30	12	Large specimens.
17	24	8–10	Average specimens.

[1] Pal. N. Y. 3:200, pl. 25, 28.

From the above we see that it is only the specimens called by Hall "large" that have a sufficient number of plications to strictly come under the species according to his description. Large specimens both from Becraft mountain and Trilobite mountain may be placed in it but the great majority are comparatively small shells with an average of nine plications on each side of the sinus. Taking the large shell as the normal, the majority, both at Becraft and Trilobite mountains, represent immature development, for the large shells have passed through this stage as seen by taking younger stages on them.

In other respects the shells are very similar, they are quite strongly incurved and gibbous at the umbo, the cardinal area is high, concave and usually equals the greatest width of the shell. The sinus of the smaller shells is not as angular as in the larger ones and in this respect approaches S. cyclopterus. The similarity to this latter species is more clearly shown in the young. The pedicle valve of S. concinnus, measuring 6mm by 8mm, has five plications and a S. cyclopterus, 5mm by 9mm has four, but in the latter species the plications are almost as pronounced as in the mature shell, while on the former they are exceedingly faint. The convexity of the two shells is very similar. Notwithstanding the close resemblance of these two species, they can hardly be very closely related since the characteristic plications of each persist from the youngest stages.

S. murchisoni Castelnau

Hall[1] speaks of the great similarity between S. murchisoni and S. cyclopterus and says that the former may be perhaps only a variety of the latter "which in the sandstone attains a larger size than in the shaly limestone below." The young of S. cyclopterus is very like that of S. murchisoni, many of the former having angular cardinal extremities similar to the latter. The hight and concavity of the cardinal area as well as the number of plications and the surface markings are also alike. But there seems to be a slight but constant, greater incurving of the pedicle valve in the former. Of course with the mature shell there

[1]Pal. N. Y. 3:430.

is no difficulty of determination. The larger size and angular cardinal extremities of S. murchisoni are readily distinguished from the smaller size and usually rounded cardinal extremities of S. cyclopterus.

S. **murchisoni** is abundantly represented in the Port Ewen,[1] Lower and Upper Oriskany.

Summary of the preceding discussion of the Spirifers

S. vanuxemi may possibly, as far as external characteristics are concerned, have been derived indirectly from the western species of S. crispus (or both from S. petilus) and has probably given rise to S. cyclopterus.

The young of S. cyclopterus could hardly have become modified into S. concinnus though they are exceedingly similar, for the finer plications of S. concinnus are present even on the youngest shell examined.

S. cyclopterus may probably have given rise to S. murchisoni for though the young of all the latter examined have a less incurving of the pedicle valve than the former, yet there is an indication of a slightly increased incurving in the younger shells over the older ones. In all other respects the young are apparently similar. Hall and Clarke indicate a close relationship between the above species.[2] They place them all under the S. crispus type.

S. arenosus (Conrad)

One specimen from the Upper Oriskany, a mere fragment of a pedicle valve, is doubtfully referred to this species.

S. macropleura (Conrad)

Exceedingly abundant in the Lower New Scotland and also in the lower part of the Upper New Scotland. It is found more usually

[1]The Port Ewen specimens are more or less transitional. They are like S. **murchisoni** in having angular plications and a subangular sinus. They are similar to S. cyclopterus in being usually small and having rounded cardinal extremities. The convexity of the pedicle valve is intermediate between the two species.

[2]Pal. N. Y. v.8, pt2, p.19, 36.

in the shale than in the limestone, e. g. it is questionably present in the dense blue limestone of K7, while 21 inches higher in K8, a dark gray shale, it is exceedingly abundant.

S. macrus Hall

Quite abundant in the lower beds of the Onondaga. No perfect valves were found. One very small specimen with a length of about 7mm and a width of 20mm has a cardinal area 2mm high and moderately concave; it has apparently six plications on each side of the sinus. Another partial pedicle valve, 10mm by 24mm, has nine plications on each side of the sinus, crossed by many lamellose, concentric striae. It looks very much like S. mucronatus but has a very much higher cardinal area. The largest specimen observed has an apparent width of 40mm.

Delthyris perlamellosa (Hall)

Abundant in the Coeymans and the whole of the New Scotland. It is very rarely found in the Becraft. This usually occurs in the same lithologic beds in the New Scotland as S. macropleura but unlike it, an apparently greater vitality enabled it to thrive in pure waters also.

Reticularia fimbriata (Conrad)

One shell from the lower Onondaga measures 22mm by 35mm by 18mm. The sinus is broad and of medium depth (not quite 2mm). The fold is quite high toward the front (3.5mm), but fades out before reaching the umbo. There are five low, rounded plications on each side of the fold and six on each side of the sinus. The concentric lamellae are quite prominent and imbricating toward the front of the shell. The specimen is much exfoliated but there appears to be an average of two elongate nodes to 1mm of width. Several specimens of fragmentary Spirifers from the upper portion of the exposed Onondaga may also belong to this species.

R. modesta (Hall)

This little spirifer is present in our collection only from the Coeymans, Lower New Scotland and Upper Oriskany.

Cyrtina rostrata (Hall)

One entire specimen and two well preserved pedicle valves found in the Lower Oriskany.

Coelospira acutiplicata (Conrad)

Very abundant in the lowest Onondaga directly above the Esopus-Schoharie. An average shell measured 10mm by 12mm by 4mm in length, breadth and thickness. This frequently occurs in the condition of pyrite casts.

C. concava Hall

One of the most abundant shells in the whole New Scotland formation, making up in places the entire rock mass; it is also one of the most characteristic species of the Port Ewen and is likewise well represented in the Coeymans. One brachial valve, 6mm by 7mm in length and breadth, from the Onondaga, seems to be identical with this species.

C. dichotoma Hall

Almost as abundant in the Upper Oriskany as L. flabellites.

C. grabaui sp. n.

Shell subovate in outline; marked by 9 plications on each valve. These plications are moderately prominent, and broadly rounded

Fig. 8 Coelospira grabaui Shimer. x2

near the front of the shell, decreasing in strength toward the cardinal extremities. The median depression of the pedicle valve is very deep from the center of the valve to the front, and contains a single plication which fades away toward the front. This produces a correspondingly accentuated elevation on the anterior portion of the brachial valve which has a strong depression down the center, thus forming two median plications, which, however, become merged into one at the front of the shell. The fold disappears at

the middle of the valve and from there to the hinge the valve is flat. In the oldest portion of the shell, i. e. from the beak to about one half the distance to the front, both valves present the appearance of a typical C. acutiplicata (Con.). But from this point to the front the valves grow rapidly toward each other, thus producing a very conspicuous thickening of the shell. With this thickening there is an increased prominence of the concentric lamellae. The dimensions of a large specimen are: length, 12mm; breadth, 16mm; thickness, 9mm.

This species which is from the very lowest Onondaga, immediately above the Esopus-Schoharie, evidently represents an offshoot of C. acutiplicata which, rapidly accentuating certain characters, soon became extinct, for it was not found in any higher beds. It must be regarded as a phylogerontic type, in which the characters normal in the adult of its ancestors are lost in its own ephebic stage.

Figured specimen, paleontologic collection, Columbia University, catalogue no. 19,326.

Leptocoelia flabellites (Conrad)

One of the most characteristic Upper Oriskany species, and occurs also less abundantly in the middle Oriskany.

Whitfieldella? nucleolata (Hall)

Very abundant in the Upper Manlius. The shell is small, an average one measuring 6mm by 5mm by 3mm in length, width and thickness respectively. It is not noticed in the Lower Manlius, while several specimens of the average size were found in the Favosites bed.

Trematospira multistriata Hall

Abundant in the Upper New Scotland; it does not vary from the description of the type.

T. perforata? Hall

Several external molds and an internal mold of the pedicle valve from the Upper New Scotland present the characters of this species.

Nucleospira concentrica? Hall

In the Lower New Scotland are many specimens of a shell which in external characters comes nearest this species but differs from it in the absence of a central, longitudinal, depressed line of the dorsal valve and in the fact that the dorsal valve is not depressed at the

beak. The average shell measures 14mm by 14mm by 6mm. The pedicle valve is convex, specially in the middle toward the beak. The brachial valve is most convex at the beak. One or two strong, concentric growth lines are usually present on each valve.

N. elegans Hall

Quite abundant in the Becraft and Lower Oriskany. A shell slightly above the average in size measures 15mm by 17mm by 8mm in length, breadth and thickness respectively.

N. ventricosa Hall

Rather poorly preserved and not abundantly represented in the Coeymans.

Meristella laevis (Vanuxem)

One of the most abundant Helderbergian species, occurring usually as perfect shells but often as internal molds. It is very abundant from the Coeymans to the Becraft inclusive.

M. lata Hall

Very abundant, specially in the Upper Oriskany. It occurs as frequently in the form of internal molds as in that of perfect shells. In a large shell of this species, the length of the striated portion of the internal mold of the muscle impress was 27mm. This was the largest specimen found. This species is also present in the Port Ewen.

The Meristella sp. of the Upper New Scotland L2 and L3 is a shell almost as broad as M. lata.

M. princeps Hall

Few specimens found but usually well preserved. One specimen was noted in the Lower New Scotland and several in the Becraft.

PELECYPODA

Pterinea? gebhardi (Conrad) var.

One large specimen from the Upper Oriskany agrees with this species in size and in the broad and not prominent radiating ribs. The grooves between the ribs have comparatively faint and narrow rays. The ribs themselves are very broad and are longitudinally striated, while the whole shell has rather faint concentric ridges,

placed about 1.5mm apart on the main part of the shell but crowded as they curve around the anterior ear. The posterior ear is not preserved but was apparently much larger than the anterior one. On the ventral part of the shell the primary ribs increase in width anteroposteriorly from $\frac{1}{16}$ to $\frac{5}{16}$ inch while the grooves increase but slightly in breadth.

P.? naviformis (Conrad)

One well preserved left valve from the Coeymans has all the characteristics of this species. Hall cites it from the Pentamerus limestone, whether lower or upper he does not say.[1]

Megambonia aviculoidea Hall

Owing to the coarsely crystalline character of these shells, they are seldom sufficiently well preserved to admit of identification for the rock on breaking fractures more easily through than around them. It is apparently quite abundant in the Upper Manlius.

Actinopteria communis (Hall)

The specimens identified with this species have rounded radiating ribs and are not nodose. One quite well preserved specimen was found in the Lower New Scotland.

A. textilis (Hall)

Very abundant in the Lower Oriskany. The surface has strong radiating ribs which at the base are distant from one another about three times their width. In the middle of each intermediate space is a finer radiating ray. Concentric ridges give a cancelated appearance to the entire surface. The large specimens from here are of a size similar to those termed small by Professor Hall.[2] A comparatively large specimen was 30mm long from tip to tip of ears and 32mm in greatest length from the hinge to the front of the shell.

A. textilis var. **arenaria** (Hall)

This differs from the above merely in having the concentric ridges accentuated, becoming imbricating lamellae and spinose where they

[1] *See* Conrad. Acad. Nat. Sci. Jour. 1842. 8:210, pl.1, for original description.

[2] Pal. N. Y. 3:288, pl.53, fig.2-10.

cross the radiating ribs. It is usually quite well preserved and was found rarely in the Lower and abundantly in the Upper Oriskany.

Cypricardinia lamellosa Hall

One rather small but quite well preserved specimen from the lower part of the Port Ewen.

GASTROPODA

Platyceras cf. **gibbosum** Hall

The specimen from the Lower New Scotland identified provisionally with this species agrees with it in shape and size of volutions. It is, however, much less strongly plicate.

P. lamellosum Hall

One specimen from the Upper Oriskany agrees exactly with Hall's figures and description[1] in size and shape. It preserves, however, no surface markings.

P. platystoma Hall

Two specimens from the Lower Oriskany answer to the description of this species.[2] They measure 35mm by 40mm and 30mm by 35mm respectively; the first measurement in each case is the diameter of the aperture at right angles to the breadth of the shell, the other is the distance in a straight line from the posterior end of the apex to the anterior side of the aperture. Each has three broad rounded plications on one side, the other being mutilated.

P. reflexum ? Hall

Two rather poorly preserved specimens from the Middle and Upper Oriskany are questionably referred to this species.

P. tenuiliratum Hall

One well preserved specimen from the Lower New Scotland.

P. ventricosum Conrad

One small specimen, 9mm in greatest length, from the Upper New Scotland and one 30mm in greatest length from the Lower Oriskany.

Platyceras sp.

A poorly preserved internal mold from the Coeymans shows three or four prominent plications toward the aperture. There is also evi-

[1] Pal. N. Y. 3:330, pl.63.
[2] Pal. N. Y. 3:326, pl.60.

dence of several rather prominent transverse folds. The spiral portion of the shell is not preserved.

Diaphorostoma desmatum Clarke

One shell from the Upper Oriskany has three volutions; its diameter through the plane of coiling is 17mm, the greatest distance at right angles to this plane is 10mm. The concentric striae are pronounced and closely crowded. The revolving striae do not cross the concentric ones and hence only modify the interspaces. This is very similar to the *young stages of* D. lineatum of the Onondaga and Hamilton above. On the adult shell of this latter species, however, the revolving striae become more and more pronounced, producing a cancelation; in the older shells the difference in the development of the two sets of striae becomes still more marked, and the cancelation becoming scarcely noticeable, the shell appears at a glance to be only longitudinally striated, the very opposite of D. desmatum.

D. nearpassi (Weller)

One small specimen was found in the Lower Oriskany. It is 8mm in greatest diameter and 4mm high. The lines of growth are crowded and raised above the surface of the shell. No revolving striae are present.

D. ventricosum (Conrad)

Shell normal in size and form. It is very abundant in the upper beds of the Oriskany where it almost invariably occurs as internal molds. It also occurs rarely in the Lower Oriskany beds and in the Lower New Scotland.

PTEROPODA

Tentaculites acula Hall

The characteristic pteropod of the Lower Oriskany where it is quite abundant.

T. elongatus Hall

Exceedingly abundant in some bands of the Upper Oriskany. It occurs much more rarely in the Lower Oriskany while one specimen was noted in the Upper New Scotland.

T. gyracanthus (Eaton)

This very characteristic Manlius fossil is very abundant both in the lower and upper portions of this formation. In one or two narrow zones of the Upper Manlius it practically occupies the bed to the exclusion of all else. The shell is normal in its development.

Conularia pyramidalis var. **jervisensis** n. var.

The specimens identified with this species are from the Upper Oriskany. They agree fully with Hall's original description of those from the shaly Helderbergian beds below, with the exception that on our shells the transverse striae are twice as numerous as on the typical species. Near the apex there are 20 striae to three lines while on the rest of the shell there are 30. Hall[1] gives 15 or 16 in three lines but says that at intervals near the aperture they are sometimes more crowded. Here the crowding has become the normal condition. The dimensions of a specimen incomplete posteriorly are 22mm in length, 9 mm in width at aperture.

CEPHALOPODA

Cyrtolites? expansus Hall

Five or possibly six specimens from the Upper New Scotland are all smaller than those described by Professor Hall.[2] The largest measures 15mm by 11mm by 16mm in width and length at aperture and length from apex to anterior portion of aperture respectively. The carination is quite prominent and two of the specimens show concentric striae. Only one specimen gives indication of a broadly expanded aperture.

Orthoceras helderbergiae? Hall

The internal mold from the Coeymans identified provisionally with this species agrees closely with the short description given by Professor Hall.[3]

Orthoceras sp.

One internal mold, 1½ inches long by ⅞ inch wide at the larger end by ⅝ inch at the smaller end, found in the Lower New Scotland,

[1] Pal. N. Y. 3:347.
[2] Pal. N. Y. 3:479, pl. 114.
[3] Pal. N. Y. 3:345.

shows 12 annulations which are angular with sharp crests. The vertical distance from furrow to ridge is about .5mm; from crest to crest of the annulations is 3.2mm. The concavity of the septum is one third of its width. No finer surface characters are preserved if they ever existed.

TRILOBITA

Proetus protuberans Hall

One well preserved pygidium with the characteristic flattened marginal border was found in the Coeymans.

Phacops logani Hall

Several specimens found in the Coeymans and New Scotland.

P. pipa Hall and Clarke

Several specimens found in the Onondaga.

Dalmanites cf. **anchiops** (Green)

A portion of a cephalon of what appears to be this species was found in the lower Onondaga.

D. dentatus Barrett

Exceedingly abundant in the ½ foot Trilobite bed, also rarely found through the entire 30 feet of the Lower Oriskany. An individual of average size measured: pygidium, 30mm by 28mm; cephalon, 30mm by 35mm in length and breadth respectively. The pygidium arched 11mm and had a spine at its end 4mm long.

D. pleuroptyx (Green)

Represented by one pygidium from the Favosites bed and another from the Coeymans, proper.

Homalonotus vanuxemi Hall

Very abundant in the lower Oriskany, specially in the Trilobite bed. A pygidium of average size measured 35mm in length by 37mm in breadth at its widest portion and arched from 4mm to 5mm.

ADDENDUM

We are indebted to Dr S. T. Barrett of Port Jervis N. Y., an active local geologist, for the opportunity of noting the two succeeding species from the Oriskany of Trilobite mountain.

Grammysia sp. nov.

One imperfect specimen of a Grammysia from the Trilobite ledge (Lower Oriskany) indicates a close relationship to G. undata of the Chemung group. It agrees with it in size and surface markings as far as these are preserved but differs from that species in that the hinge line anterior to the umbone has a greater extension and that the convexity of the shell posterior to the cincture is decidedly greater.

Nuculites barretti sp. nov.

Shell outline characterized specially by an abrupt downward curving to the hinge line posterior to the beak and by an oblique

Fig. 9, 10. Nuculites barretti Shimer. x2

truncation anterior to the hinge line, as well as by the navicular curve of the base. Beaks separated by an area of medium width. Dentition taxodont, apparently multivincular. Anterior to the beak is a radial buttress[1] extending from the hinge line downward and slightly forward about one third of the distance to the base of the shell. The internal molds from which this description is made show on the umbone a slight depression running parallel to the radial buttress. An undefined sinus gradually broadening extends from the hinge line to the posterior basal extremity.

Three specimens measure in length and hight respectively, 19mm by 8mm, 20mm by 12mm (imperfect), 16mm by 10mm (imperfect).

This species, which is from the Upper Oriskany, more closely resembles in external characters Clidophorus cuneatus Hall of the Upper Ordovician[2] than any other species with whose description we are familiar. It differs specially, however, from C. cuneatus in being more elongate in proportion to its hight, in the more central location of the beaks and in the abrupt downward curving to the hinge line posterior to the beak.

[1]On comparing the radial buttress of this species with that of Machaera costata, a recent shell abundant along the whole New England coast, we note that in the latter species it is perpendicular to the shell and also is narrowest at the hinge line, increasing in breadth as it fades away, in this respect being just contrary to Nuculites barretti.

[2]Can. Nat. & Geol. 1860. 5:148.

Table showing faunal distribution according to horizons[1]

	MANLIUS		COEYMANS		NEW SCOTLAND				ORISKANY		
	Lower	Upper	Favosites bed	Coeymans proper	Lower	Upper	Becraft	Port Ewen	D. dentatus horizon	S. murchisoni horizon	Onondaga
Spongia											
1 Hindia fibrosa *Roemer*	....	....	....	....	?	....	....	....	....	....	....
Hydrozoa											
2 Stromatopora concentrica ? *Goldfuss*	....	....	r-C	....	....	....	....	....	....	....	....
Actinozoa											
3 Blothrophyllum promissum *Hall*	....	....	....	....	....	....	....	....	....	....	?
4 Ceratopora *sp.*	....	....	....	....	....	....	....	....	....	....	?
5 Enterolasma strictum *Hall*	....	....	....	c	c-C	r-c	r	r	....	....	....
6 Favosites helderbergiae *Hall*	....	r	c-C	c-C	....	....	....	....	....	....	....
7 F. sphaericus *Hall*	....	r	?-C	r-c	r	....	....	....	....	....	....
8 Favosites *sp.*	....	....	....	r	r	....	....	....	....	....	R
9 Zaphrentis roemeri *E. & H.*	....	....	r	....	....	....	....	....	....	....	....
10 Zaphrentis *sp.*	....	....	....	....	....	....	....	....	....	....	?
Pelmatozoa											
11 Edriocrinus pociliformis *Hall*	....	....	....	....	....	....	c-C	....	....	....	....

[1] The classes are arranged in zoologic order; the species are in alphabetic order.
C indicates very common; c, common; r, rare and R, very rare.
The two letters in a square indicate the range in abundance of that species in the beds in which it occurred at all; for example, number 33 occurs rarely, commonly or very abundantly in the different beds of the Upper New Scotland, yet in some outcrops it was entirely wanting. Gypidula galeata of the Coeymans proper is practically the only species which is present in every outcrop; though several other species approach it in this respect, noticeably Spirifer murchisoni in the Upper Oriskany and Spirifer concinnus in the Becraft.

Bryozoa											
12 Lichenalia torta *Hall*			r	r-c		R-c	r	r			
13 Lioclema cellulosum *Hall*				c	?						
14 L. ponderosum (*Hall*)					r						
15 Monotrypa tabulata *Hall*					R						
16 Monotrypella ? abrupta (*Hall*)		?			c				?		
17 Orthopora regularis (*Hall*)				c	c						
18 O rhombifera (*Hall*)				C	C						
19 Unitrypa nervia (*Hall*)				r							
20 U. praecursa (*Hall*)				c	?						
21 Vermipora serpuloides *Hall*					c	r			c		
Brachiopoda											
23 Atrypa reticularis *Linn.*				r-c			r-c				C
24 Atrypina imbricata *Hall*					R	c					
25 Beachia suessana *Hall*									R-c	R	
26 Bilobites varicus (*Con.*)					r						
27 Chonetes hemisphericus *Hall*											?-c
28 C. hudsonicus *Clarke*					r						
29 C. yandellanus *Hall*											R
30 Chonostrophia complanata *Hall*						R			r-C	r	
31 C. jervisensis *Schuch*										r	
32 Coelospira acutiplicata (*Con.*)											R-C
33 C. concava (*Hall*)				r	r-c	r-C		r-C			R
34 C. dichotoma (*Hall*)										r-c	
35 C. grabaui *Shimer*											C
36 Cyrtina rostrata *Hall*									r		
37 Cyrtina *sp.*				R							
38 Dalmanella concinna *Hall*								r			
39 D. perelegans *Hall*				r		r					
40 D. subcarinata *Hall*				r-c	r-c	r-C	r	r	R-c	r	?

Table showing faunal distribution according to horizons (*continued*)

		MANLIUS		COEYMANS		NEW SCOTLAND				ORISKANY		
		Lower	Upper	Favosites bed	Coeymans proper	Lower	Upper	Becraft	Port Ewen	D. dentatus horizon	S. murchisoni horizon	Onondaga
	Brachiopoda (continued)											
41	Delthyris perlamellosa *Hall*				c	R-c	R-c	?-R				
42	Eatonia medialis (*Van.*)				r	R C	r-c					r
43	E. singularis (*Van.*)					R-c	R		c			
44	Gypidula angulata *Weller*				R							
45	G. galeata (*Dal.*)				c-C							
46	G. pseudogaleata (*Hall*)							C				
47	Leptaena rhomboidalis (*Wilck.*)				c-r	c-r	c-r	r-C		R-c		r
48	Leptocoelia flabellites (*Con.*)										r-c	
49	Leptostrophia oriskania *Clarke*									R		
50	Lingula *sp.*					r	c		R			
51	Megalanteris ovalis *Hall*										?	
52	Meristella laevis (*Van.*)				c-C	R-C	r-c	R-C				
53	M. lata *Hall*								r	r	r-C	
54	M. princeps *Hall*					R		r				
55	Meristella *sp.*					R	r-c					R
56	Nucleospira concentrica *Hall*					r						
57	N. elegans *Hall*				?			c		c		
58	N. ventricosa *Hall*				r		?					
59	Orbiculoidea ampla *Hall*									r		

60	O. discus *Hall*					?	?					
61	O. jervisensis (*Barrett*)					?				c	C	
62	Orthothetes woolworthanus *Hall*						r	R				
63	Pholidops ovata *Hall*				c	r						
64	Rensselaeria aequiradiata (*Con.*)			c f			c f			R		
65	R. ovoides (*Eaton*)									?		
66	R. subglobosa *Weller*									c-C		
67	Reticularia fimbriata (*Con.*)											r
68	R. modesta (*Hall*)				r	r					r	
69	Rhipidomella assimilis *Hall*					R						
70	R. eminens *Hall*						r					
71	R. oblata *Hall*				R	r	r-R			r		
72	R. tubulistriata *Hall*						R					
73	Rhynchonella altiplicata *Hall*				?		?					
74	R. bialveata *Hall*					?						
75	R. semiplicata (*Con.*)				?-r							
76	Rhynchospira formosa *Hall*				c	R						
77	R. globosa *Hall*				?							
78	Schizophoria bisinuata *Weller*				?							
79	S. multistriata *Hall*				?		R	R		?		
80	Spirifer arenosus (*Con.*)										?	
81	S. concinnus *Hall*							c-C				
82	S. cyclopterus *Hall*				C	r	r-C	R-r			R	
83	S. macropleura (*Con.*)					R-C	c-C					
84	S. macrus *Hall*											c
85	S. murchisoni *Castel*								c	r-c	r-C	
86	S. vanuxemi *Hall*	r-C	R-C									
87	Stenocisma formosa (*Hall*)						R			r		
88	Stropheodonta becki *Hall*				r-c	r	r-c	r	r		r	
89	S. varistriata (*Con.*)	r-C	R-C	r	? r							
90	S. varistriata arata *Hall*				r		r					

Table showing faunal distribution according to horizons (*continued*)

	MANLIUS		COEYMANS		NEW SCOTLAND				ORISKANY		
	Lower	Upper	Favosites bed	Coeymans proper	Lower	Upper	Becraft	Port Ewen	D. dentatus horizon	S. murchisoni horizon	Onondaga
Brachiopoda (continued)											
91 Strophonella ? conradi *Hall*									r		
92 S. headleyana *Hall*					r	r	?				
93 S. leavenworthana *Hall*								R			
94 S. punctulifera (*Con.*)				r		r-R	R	r			
95 Trematospira multistriata *Hall*						R-c					
96 T. perforata *Hall*						?					
97 Uncinulus campbellanus (*Hall*)						R	?				
98 U. mutabilis *Hall*				?-r							
99 U. nucleolatus *Hall*				c							
100 U. pyramidatus *Hall*				c		R					
101 U. vellicatus *Hall*						R			R		
102 Uncinulus *sp.*		r		r							
103 Whitfieldella ? nucleolata (*Hall*)		c-C	r								
Pelecypoda											
104 Actinopteria communis (*Hall*)					R						
105 A. textilis (*Hall*)									R-C		
106 A. textilis arenaria (*Hall*)									R	c	
107 Cypricardinia lamellosa *Hall*								R			
Grammysia *sp. nov.*											

108	Megambonia aviculoidea *Hall*		r									
	Nuculites barretti *Shimer*											
109	Pterinea ? gebhardi (*Con.*) var.										r	
110	Pterinea ? naviformis (*Con.*)				R							
	Gastropoda											
111	Diaphorostoma desmatum *Clarke*										r	
112	D. nearpassi (*Weller*)									R		
113	D. ventricosum (*Con.*)					R				R	r-C	
114	Holopea antiqua (*Van.*)		?									
115	Loxonema jerseyense *Weller*									?-c		
116	Loxonema *sp.*	R	r									c
117	Platyceras gibbosum *Hall*					cf						
118	P. lamellosum *Hall*										R	
119	P. platystoma *Hall*									r		
120	P. reflexum *Hall*										?	
121	P. tenuiliratum *Hall*					R						
122	P. ventricosum *Con.*						R			R		
123	Platyceras *sp.*				R	R	R			R	R	
124	Pleurotomaria *sp.*		R									
	Pteropoda											
125	Conularia pyramidalis jervisensis *Shimer*										r	
126	Tentaculites acula *Hall*									r-c		
127	T. elongatus *Hall*						R			r	r-C	
128	T. gyracanthus (*Eaton*)	c-C	R-C									
129	Tentaculites *sp*				r							
	Cephalopoda											
130	Cyrtolites ? expansus *Hall*						c					
131	Orthoceras helderbergiae *Hall*				?							
132	Orthoceras *sp.*					r						

Table showing faunal distribution according to horizons (*concluded*)

		MANLIUS		COEYMANS		NEW SCOTLAND				ORISKANY		
		Lower	Upper	Favosites bed	Coeymans proper	Lower	Upper	Becraft	Port Ewen	D. dentatus horizon	S. murchisoni horizon	Onondaga
	Trilobita											
133	Dalmanites anchiops (*Green*)											cf
134	D. dentatus *Barrett*									R C		
135	D. micrurus (*Green*)		R									
136	D. nasutus (*Con.*)				?							
137	D. pleuroptyx (*Green*)			R	?-R							
138	Dalmanites *sp.*						R-r		R			
139	Homalonotus vanuxemi *Hall*									c		
140	Phacops logani *Hall*				R	r	cf					
141	P. pipa *Hall & Clarke*											r
142	Phacops *sp.*										R	
143	Proetus protuberans *Hall*				R							
	Ostracoda											
144	Beyrichia manliusensis *Weller*	?-c	?-r									
145	Beyrichia *sp.*	r	r-c	?								
146	Leperditia alta (*Con.*)	r	R-c									

I wish to express here my indebtedness to Prof. A. W. Grabau of Columbia University, under whose supervision this work was prosecuted and who has given me continuous encouragement in the work.

BIBLIOGRAPHY

Barrett, S. T. 1876. Notes on Lower Helderberg Rocks of Port Jervis, N. Y. and Descriptions of a New Pteropod. N. Y. Lyc. Nat. Hist. Ann. 11:290 and Am. Jour. Sci. Ser. 3. 13:385-87.

——— 1878. Coralline or Niagara Limestone of the Appalachian System. Am. Jour. Sci. Ser. 3. 15:370.

——— 1878. Descriptions of New Species of Fossils from the Upper Silurian Rocks at Port Jervis, N. Y., with notes on the occurrence of the Coralline limestone at that locality. N. Y. Acad. Sci. Ann. 1:121.

——— 1893. Note on Paper in Nov. number of Am. Jour. Sci. on a New Oriskany Fauna in Columbia County, N. Y. Am. Jour. Sci. Ser. 3. 45:72.

Beecher, C. E. & Clarke, J. M. 1892. Notice of a New Lower Oriskany Fauna in Columbia County, N. Y., with an annotated list of fossils. A. J. S. (3) 44:410-14.

Clarke, J. M. 1901. Indigenous and Alien Faunas of the N. Y. Devonic. N. Y. State Mus. 55th An. Rep't, p.664-72.

——— 1900. Oriskany Fauna of Becraft Mountain, Columbia County, N. Y. N. Y. State Mus. Mem. 3, p. 128.

——— **& Beecher, C. E.** 1889. Development of some Silurian Brachiopoda. N. Y. State Mus. Mem. 1.

Darton, N. H. 1892. Report on the Relations of the Helderberg Limestones and Associated Formations in eastern New York. N. Y. State Mus. 47th An. Rep't, p. 393.

Grabau, A. W. 1900. Siluro-Devonic Contact in New York. Geol. Soc. Am. Bul. 11:347-76.

——— 1902. Stratigraphy of Becraft Mountain, Columbia County, N. Y. N. Y. State Paleontol. An. Rep't, p. 1030-1108.

Hartnagel, C. A. 1902. Preliminary Observations on the Cobleskill ("Coralline") Limestone of New York. N. Y. State Paleontol. An. Rep't, p. 1109-75.

Horton, William. 1839. Report on the Geology of Orange County, N. Y. N. Y. State Geol. An. Rep't, p. 150, 151.

Ries, Heinrich. Report on the Geology of Orange County. N. Y. State Geol. An. Rep't, 15:395.

——— 1898. Notes on a Trip from Port Jervis to Rondout, N. Y. N. Y. State Mus. 52d An. Rep't, 1:188.

Schuchert, Charles. On the Lower Devonic and Ontaric Formations of Maryland. U. S. Nat. Mus. Proc. 26:413-24.

——— Fossils near Montreal, Canada. Am. Geol. 27:250. (Names a fossil, Chonostrophia jervisensis, after Port Jervis).

Ulrich, E. O. & Schuchert, Charles. 1901. Paleozoic Seas and Barriers in Eastern North America. N. Y. State Paleontol. An. Rep't, p.633-63.

van Ingen, Gilbert, & Clark, P. E. 1902. Disturbed Fossiliferous Rocks in the Vicinity of Rondout N. Y. State Paleontol. An. Rep't, p. 1176-1227.

Weller, Stuart. 1902. Report on Paleontology. Geol. Sur. N. J. v. 3, various references.

White, I. C. 1882. Pennsylvania Geological Survey. Report G6, various references.

CONTRIBUTIONS TO THE FAUNA OF THE CHAZY LIMESTONE ON VALCOUR ISLAND, LAKE CHAMPLAIN

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The following descriptions have been made in order to facilitate the study of a section in the Chazy rocks on Valcour island. All the species were obtained from the beds of this section.

CYSTOIDEA

Genus MALOCYSTITES Billings

Malocystites emmonsi sp. nov.

Plate 1, figures 3-7

Description. Viewed from above along an axis determined by the point of attachment to the stem and the center of the more globular portion of the theca, and with the food grooves or what I may call the sigma, turned away from the observer, the anus appears to be placed a little to the left and more or less in advance of the summit; this axis measures from 6 to 10 mm. Viewed from the right side, that portion of the theca bearing the rather prominent plates of the sigma is seen to be produced so as to form a distinct and somewhat contracted neck with the mouth from 40 to 80 degrees in advance of the distal end of the axis as defined above; the edge of the theca from base to anterior food groove is much flattened forming in most cases a rather straight line or chord of from 90 to 140 degrees; the posterior edge is also rather straight or but slightly convex, forming a chord of some 45 degrees from base; from here the outline is usually well rounded to neck under edge of posterior food groove, though some specimens are rather obliquely oval or subovate in outline; the longest diameter is from base to outer edge of posterior food groove and is from one fifth to one fourth longer than the measured vertical diameter. There are on an average some 43 plates in all, not counting the covering pieces, and their outlines usually vary from tetragonal to heptagonal. Some of the specimens

are in part ornamented with fine regular, rounded, and not crowded granulations, while in others the raised granulations become quite irregular in outline and often confluent. The larger plates have each a more or less prominent umbo, which may be central or excentric and which together give various angular outlines to different portions of the theca; there is usually a very large umbo between the anus and the base. More or less wide, raised ridges usually connect the umbones and many finer ridges run from them over the plate, branch, cross the sutures and form some very fine reticulations having rounded, depressed pits between them.

Observations. This species differs from M. barrandii in its much smaller size, the excentric position of the anus, the outgrowth of the theca to form a neck under the sigma, its conical base, its prominent umbones and varied angular outlines. Mr Percy E. Raymond writes me that the food grooves in the type specimens of M. barrandii are not so much elevated in proportion to the size of the theca as in this Valcour form.

These specimens are so well preserved that it seems proper to make their description still more complete. Specimen A, which has been chosen as the type, still bears two rings of the stem and shows it to have had a marked and permanent bend toward the posterior side. Another specimen has six rings of the stem still attached; these are circular, measure 1.2 mm across next to the theca and uniformly taper down to .9 mm without alternations in size. The outer surface of the joints is only gently convex and each joint is very faintly and closely ribbed across its edge; there are about six rings to the millimeter; here also a rather abrupt bend toward the posterior side occurs next the theca and it is rather difficult to distinguish the sutures between the first two or three rings; the lumen is round and about half the diameter of the ring. The stem appears to have been short and used perhaps as an anchor but not for complete support. The theca probably rested, in part at least, on the plates to the posterior of the proximal ring. This position would place the mouth at the summit of the theca and bring the arms into a horizontal plane and a similar external environment. Figures 4, 6 and 7, plate 1, show three specimens oriented as if supported by

the stem alone, making the axis chosen for description the vertical axis on the plate. A glance at figure 7 will perhaps show the absurdity of considering this a normal position, particularly so if the sigma plates bore spreading brachioles, as their structure suggests. The posterior arm is usually the shorter and less developed, the difference in environment caused by the position of the anus being the probable cause.[1]

The plates of the type specimen, designated as A [pl. 1, fig. 3, 4] are arranged as follows. There are three basal plates, the anterior of which is about half the size of the others. This plate is in contact with but two plates lying above it, while each of the other two is in contact with four plates above. Numbering to the right from the posterior margin, plate 4 rests on the upper left side of plate 1, this plate and the next are tetragonal and small; no. 6 is heptagonal, large, and has a prominent and excentric umbo a little above and to the right of the center; plates 7 to 9 are nearly as large as 6, are

[1] I have for some years harbored a notion that one of the many laws underlying the production of variation and new species might be expressed by the term, "the survival of the unfit," perhaps better stated as "the survival of the weak," a law related to Cope's "law of the unspecialized." Failure to divide normally at the proper time gave cell aggregates and inaugurated a new wave in what Herbert Spencer points out as the law of rhythm in evolution. No new crest of strength springs from the crest of the last wave but each crest is preceded by a trough. The invagination of a weak hollow sphere of cells gave rise to the gastrula and forced a division of labor on the "unfortunate" aggregate; and this law, if I may so call it, offers suggestions as to the origin of many things from cell conjugation to the discovery of some weak mortal that he might make the pen mightier than the sword he was unable to use. The idea suggested a possible cause for the later change in shape of Eunema epitome. Lyriocrinus? beecheri, with its invaginated base produced at first by the yielding of weak basals to the persistent attack of gravity, is an illustration in point and an extreme is found in Blastoidocrinus carchariidens. The failure of plates to support increased weight has initiated variation along this line in many crinoids and natural selection has found certain mechanical advantages in the new forms; out of weakness has come strength. The law suggests that ancestors of Malocystites were once supported by the stem alone and had their arms in a normal position, but that descendants with weak stems often found themselves let down to the ocean floor and had to make shift to live under adverse conditions. Increased growth of the posterior plates or decreased growth of the anterior plates would have brought the arms again uppermost and given rise to a form like that here shown. A stem unused for support might become of advantage as an organ of locomotion and secure slow changes in position.

hexagonal, and have slightly raised centers; plate 10 is the last to have a side in contact with any of the basal plates, it is pentagonal and about the size of no. 7. Plate 11 is a large pentagonal plate and may be considered as the first in the third row, though it is so wedged

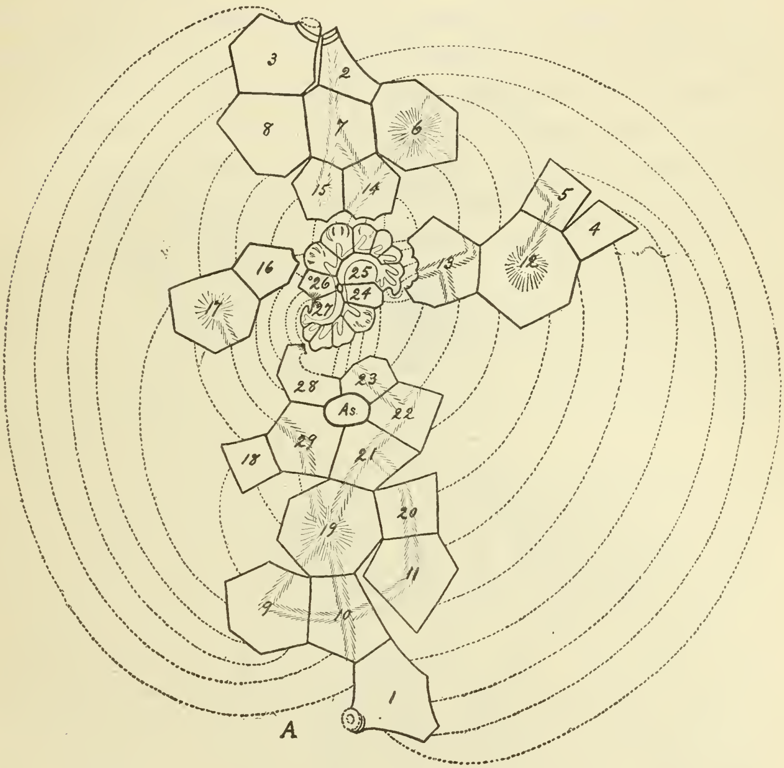

Fig. 1 Analysis of the type specimen, designated as specimen A, of Malocystites emmonsi. The mouth with its plates bearing the food grooves will be found just above the center of the diagram; the anus (As) not far below it; the basals are numbered 1, 2 and 3 and will be found at the extreme upper and lower portions of the figure. The more prominent mounds and ridges have been rather roughly indicated by hachures.

in between plates 10 and 4 as to have its lowest angle touch the highest angle of plate 1; the center of this plate lies a little to the right of a line drawn from anus to base and is the lowest of three that might be called the anal row. Passing still to the right, no. 12 is the largest of the remaining plates with one exception, is heptagonal, and bears a moderate umbo. Plate 13 supports the fifth and the following brachials (if I may so call these plates) of the anterior arm; plate 14 supports the third brachial of this arm and also half

of the second and nearly all of the fourth brachial. The latter arm plate has a small shoulder against no. 13. Plate 14 is marked by a prominent ridge connecting with the umbo on plate 6 and the place of meeting of plates 13, 6 and 14 is depressed. Plate 15 supports

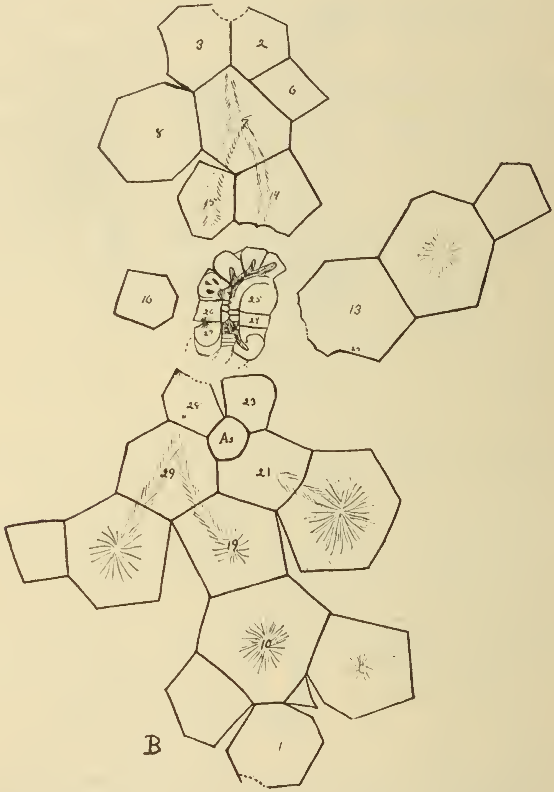

Fig. 2 Analysis of Malocystites emmonsi, specimen B [pl. 1, fig. 5, 6]

half of each of the first and second brachials, plate 16 has one shoulder against the first brachial and supports also the plate bearing the genital pore. The plates now leave the arm, 17 is moderately large, hexagonal and with a slight umbo just above its center; 18 is small and tetragonal; 19 is as large as any of the others, is hexagonal and has a very prominent and nearly central umbo; this completes the third row and is the last of the plates bearing umbones. Plate 20 comes directly over 11 and plate 21, above this, forms the

lower border of the anus; plates 22 and 23 form the right and a portion of the upper border of the anus, and 23 also supports the first and half the second brachial of the posterior arm. Plate 24 is just anterior to and also supports the first brachial of this arm, it also reaches the mouth and forms part of its border; plate 25 is semicircular in outline, fills up the inner portion of the half sigma of the anterior arm and supports all of its brachials on this side; its inner border is raised to form the edge of a channel which receives the eight grooves of the anterior brachials. Plate 26 borders on the mouth, supports the posterior edge of the first anterior brachial, and bears the genital pore; 27 is formed like 25 and receives the six grooves of the posterior arm; 28 supports the last brachials of the posterior arm on the outer side of the curve and with 29 forms the left border of the anus. At the point where plates 26, 27 and 28 meet each other there is a peculiar, small, roughened mound which may represent the madreporite.

There is considerable variation in the plate arrangement in the three specimens figured. Specimen C was probably as aberrant a form as could have been found in the two hundred or more specimens collected. This specimen has 37 plates besides the brachials, A had 29, and B shows but 28.[1] The four plates bordering the mouth are constant and may be called the orals. They bear covering plates some of which may be seen in specimen B [pl. 1, fig. 5]. The plates I have called brachials are vertical plates with their lower edges resting on the neck plates of the theca and their middle portion against the opposite oral. These plates do not show covering pieces but the orals numbered 25 and 27 still continue their covering pieces which now reach completely across the food groove, forming a single series of rectangular plates. There were several of these in position on the anterior arm but they became lost through an accident and the only completely transverse plates now present are in the posterior arm. The first one or two brachials are the largest; the others then grow rapidly smaller as the half sigma recedes from the mouth. All bear truncate faces on their distal ends and the larger are marked as if they had borne extended and movable brachioles. The larger faces are directed more nearly upward and

[1]Compare figures 1, 2 and 3 of the text.

bear two crescentic depressions which face each other; their inner ends reach to the edge of the food groove; and partly inclosed between them is a third somewhat triangular depression pointing toward the food groove but situated nearer the outer edge of the

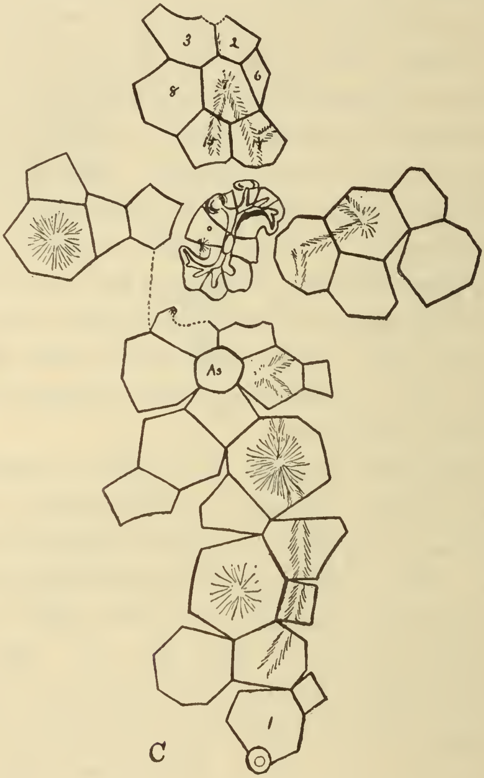

Fig. 3 Analysis of Malocystites emmonsi, specimen C [pl. 1, fig. 7]

plate. Surrounding all is a well rounded but not prominent ridge. The smallest plates seem to have had short extensions which were bent below the horizon of the sigma. Going toward the larger plates the angle of each truncate face gradually changes till we reach the larger and more vertical brachioles. The normal specimens have six grooves running into the posterior portion of the sigma and eight into the anterior portion, but it is difficult to determine whether these grooves represent so many separate plates. The last two are very small and I have as yet been unable to detect a suture between them.

Specimen C has but 10 radiating grooves in the complete sigma, five in each half. Specimen B seems to have no genital pore and the ornamentation of the plates varies considerably from that of A. The position of the madreporite is constant in all.

The anus is large, usually appearing as a rounded pentagon. The covering plates in some of the specimens seem to have been pressed into the anal opening; one specimen has the plates in position and they form a gently convex mound, the plates meeting so exactly that the determination of their number, whether five or six, is no easy matter. They are ornamented by radiating lines of exceedingly fine and close tubercles.

The specimens so far examined have each six neck plates, but there is much variation in their manner of supporting the plates of the sigma. The three basals seem to be constant with no. 2 always the smaller. The plate numbered 7 seems also constant in shape and position and the two plates directly above it always reach and support the sigma plates above them. In the figures illustrating the cup dissections I have crudely indicated the more marked umbones and the more prominent ridges connecting the same. Further study would no doubt enable one to designate many more of these plates as constants. The specific inheritance had not become as yet so fixed as to completely shut out some of the plates of an older inheritance. The anterior plates were evidently less disturbed in their early growth and so have more nearly a constant shape. Name given in honor of Dr Ebenezer Emmons, former state geologist of New York.

CRINOIDEA

Genus LYRIOCRINUS Hall

Lyriocrinus? beecheri sp. nov.

Plate 3, figures 1-4

Description. Cup small, but 6mm from base to upper angle of primaxil [1Ax], while the whole crown from base to top of incurved arms is 21mm; the cup has been crushed and thus slightly widened, but the greatest width still measures but little over 7mm. Proximal joint of column round and sunken in a hollow base formed by a strong infolding of the proximal portion of the basals; column next

the cup formed of alternate narrow and wider rings. The basals appear to be hexagonal and each is marked by two very prominent keels running from the central portion of the plate toward the lower angles. Both are bent, with the convex side toward the ring; at their junction near the center of the plate they give rise to a short vertical fold which soon divides into two less prominent keels or

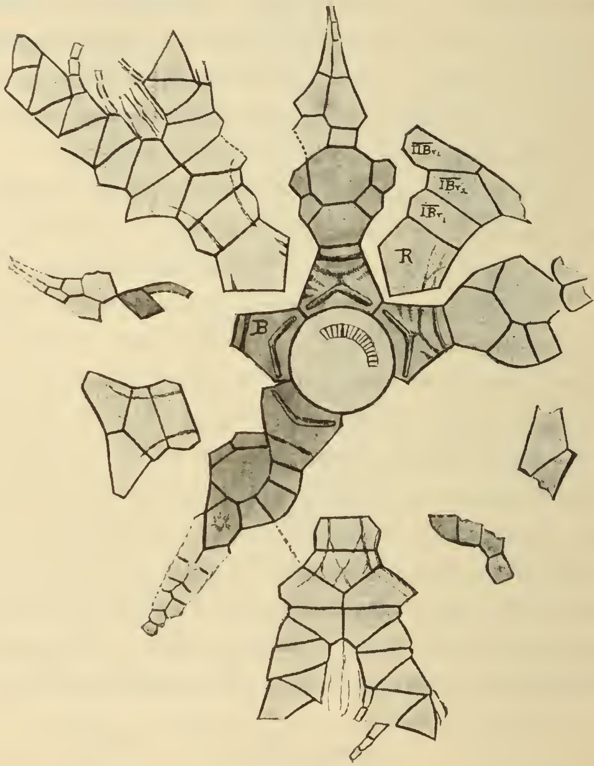

Fig. 4 Analysis of Lyriocrinus? beecheri. Interradial plates shaded and the position of the more prominent plate folds and ridges indicated.

ridges which pass outward to the radials; between the former and the latter are three faint folds, seen best next the edge of the plate and perpendicular to this edge; there is also a strong transverse ridge below and parallel with the truncate upper edge of the plate. The pentagonal, completely separated radials carry very slightly raised ridges continued from the basals; those near and parallel with the lateral margins are the more prominent and extend vertically

over the brachials at about one fourth the width of the plates from their margins, as fine, raised ridges; these fork near the upper edge of IBr (first primibrach), and again just as they leave the IAx; the outer branch in each case remains the stronger but becomes very faint on $IIBr_1$. The first secundibrach ($IIBr_1$) is about twice as wide as high and the pentagonal IAx presents approximately the same area of surface. These plates seem to be ornamented only by what appear to be faint nerve ridges and their branches which present some very faint reticulations. No ray seems to have possessed a plate between IBr_1 and IAx. Each interradius has one large plate in contact with the basals, and six or seven plates in addition, one of which may be as large or slightly larger than the first; directly over these the pinnules from $IIBr_1$, with their plates somewhat enlarged, meet each other and are incorporated in the cup. The 10 arms, thus brought closely together, are comparatively large, biserial and, with their pinnules, obovate in outline; the IIBr counted on one side number 35 and over and are strong and rounded on the back; the pinnules are closely set and the longest measure about 5mm; the whole arm is very plumelike in appearance and the manner of folding over the cup extremely graceful. This folding is a mixture of the convolute and imbricate and is shown in figure 5.

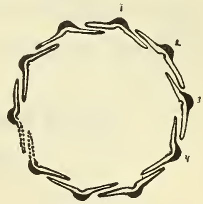

Fig. 5 Diagrammatic cross-section of Lyriocrinus? beecheri showing the manner in which the arms are folded over the tegmen.

Observations. The crushed condition of the cup has made the determination of the arrangement of the plates of the interradii a somewhat difficult matter. In my drawing of this plate arrangement (fig. 4), I have outlined only such plates as were present and in, or nearly in, their normal position. In one or two instances a fracture may have been taken for a suture. The complete interradius to the right in the cut was drawn from plates crushed in just below the first incorporated pinnules and perhaps should have one or two additional small plates near the latter. The completed interradius placed in the position of l. anterior IR apparently has had its basal, the top of which is broken across, forced to one side. This inter-

radius seems to possess two or more very small tetragonal plates lying between but not belonging to the enlarged pinnules from $IIBr_1$; it should perhaps have been chosen to represent posterior IR. Owing to the condition of uncertainty I have refrained from completing the diagram and have made the left hand interradius of figure 1 [pl. 3] the vertical one in figure 4 of this text.

I am one of a host whom Prof. C. E. Beecher placed under lasting obligation through his kindly given and generous help. This specimen was found soon after his visit to my camp in the summer of 1903 and I name it after him, not alone in recognition of the eminent position he attained in the science to which he gave his life's labor, but also as a token of personal affection and in appreciation of many rare mental qualities which I came to see as one can best see such things through the freedom of field work by day and at the open camp fire by night.

Genus RHAPHANOCRINUS Wachsmuth and Springer

Rhaphanocrinus gemmeus sp. nov.

Plate 2, figures 1-5

Description. Cup small; its hight measured from proximal surface of basals to distal angle of first secundibrach 7.5mm; its diameter measured from upper edge of right posterior primaxil about 9.6mm; that of its base across lower shoulders of basals 4mm; that of proximal ring of stem 3.3mm; sides of cup from lower edge of basals to top of radials rather straight and from this point gradually curving to give a somewhat vertical edge to cup at IIB_1. The more or less narrow depressed margin of the plates is ornamented by numerous fine radiating lines which cross the sutures; a single large proximal interbrachial possesses more than 40 of these lines, and under a low power they are seen to be rows of fine tubercles; from the inner edge of this border the plates rise rather abruptly to the hight of about .5mm and become smooth or microscopically granular with a large flat or slightly concave area which shows, near its outline, a marked tendency toward suppression of the plate angles. The infrabasals are small and almost completely covered by the proximal ring of the

stem. Near the cup the stem is made up of alternating light and heavy rings, slightly flattened on their radial edges and possessing radially disposed sutures. The basal plates are largest and are transversely depressed as if slightly bent outward at their bases or as if impressed with a quadrangular die that left four shallow pits at its four corners. The radials are next in size, their raised areas are nearly circular in outline and about 2mm in diameter; they also show slight traces of lateral impressions similar to those on the basals; the raised areas on these plates and on the basals are so large as to nearly or fully meet at the plate edges midway between the angles. The first brachials are smaller and their raised surface wider than high, this area showing a tendency to become diamond-shaped; the plates of the radii above these brachials are well rounded and smooth save for a single depression shown by the anterior and right anterolateral primaxils. The proximal interbrachials are but little smaller than the basals and their raised areas are more angular in outline and well separated from those of the adjoining plates; each supports two smaller plates and these in turn three others above them; a few smaller plates above the latter lose the smooth rounded subcentral elevations and present but a short, vertical, median ridge. In the posterior interradius there is an extra plate immediately above the anal which is followed by a vertical row of seven and perhaps more smaller regular hexagonal plates. The anal tube is about 2.3mm in diameter; rises with a slightly broader base, from a position but little posterior to the center of the oral surface; is bent down just above the ninth hexagonal plate of the anal row; curves slightly to the right and then back to the left and its tip nearly touches the $IIBr_4$ of the anterior R; the last part, 4mm in length, consists of about 10 rows of plates each .4mm long and the row so twisted as to bring a plate

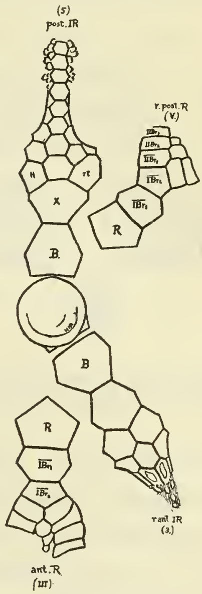

Fig. 6 Analysis of Rhaphanocrinus gemmeus. Three radii and three interradii not shown.

of one row directly under a plate of the next.[1] Some pinnules appear to have been incorporated in the lower portions of the tube. Arms above the $IIBr_4$ are wanting in the specimen. Intersecundibrachs present.

Genus CARABOCRINUS Billings

Carabocrinus geometricus sp. nov.

Plate 1, figures 1-2

Description. Cup small, its hight from base to level of upper edge of anal x, 6.5mm, its width measured across from base of left

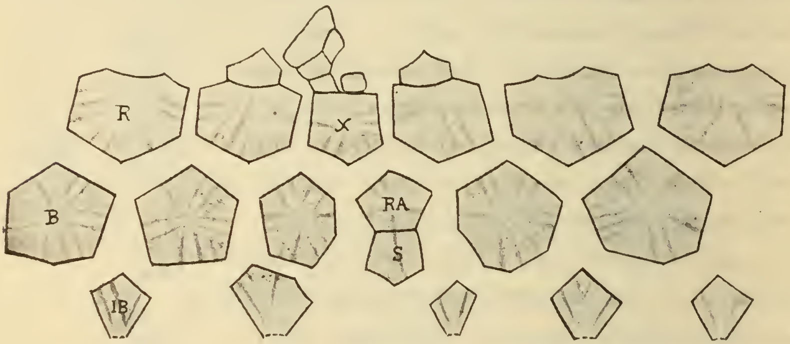

Fig. 7 Analysis of Carabocrinus geometricus. The outline of the radials is drawn as viewed from the side and the true outline of the oral edges is not seen. The more easily detected axial folds have been shown by shaded lines.

posterior IAX 7.5mm, its width half way between base and last measured diameter 6.5mm, subhemispheric with a slight vertical elongation and a tendency to show inversely conical outlines along the lines from base through the centers of the RR, particularly in the l. posterior R where the flattening of the side of the cup is well marked. Vertical diameter of the IBB a little less than that of the RR and their transverse diameters about one half of the latter; the IB of l. posterior R is a little larger than the others and pentagonal, one shoulder supporting the supplemental anal plate, the others are all tetragonal; the IB of r. posterior R is smaller than the others. The vertical and lateral diameters of the BB are about equal to the

[1]It will be seen that such a twist, if I may so call it, could be described as turning either to the right or to the left, or one might consider the tube to be formed of about 20 longitudinal rows of plates without "twist" but with the plates offset.

width of the RR; the B of R posterior IR is heptagonal, the other four are hexagonal. The plates of the anal row are pentagonal, the anal x is about two thirds of the width of the RR on either side of it, its vertical diameter is the same, one edge is uppermost and the two vertical edges are nearly parallel; the radianal is a little smaller with one angle uppermost and its sides of very nearly the same length; the supplemental plate is slightly smaller still, of nearly the shape of the anal x and with an angle down. The RR have raised centers and the axial folds of these plates pass across the sutures and over the neighboring plates after the manner of C. radiatus, but the folds are finer and less prominent. The plates are very faintly tuberculate, the tubercles showing rather more plainly along the upper edges of the axial folds. The first Br is also the IAX, it is pentagonal, stout, nearly or quite half the width of the R, and well rounded on the back; the hight of the outer edges is about one fourth of the width of the plate.

A very small portion of the tegmen is present in posterior IR; the relative size and position of the plates will be seen in plate 1, figure 2. At each of the other four junctions of the RR in the periphery of the tegmen there is a shallow excavation of the plate margins, forming a straight base and an acute angle at either end as if cut for a dovetail. This appearance suggests triangular deltoids with a bordering plate on either edge, but as I am not familiar with the tegmen of crinoids and do not have easy access to the literature of the subject I shall refrain from further suggestion.

Attached superficially to the left edge of l. posterior R there appears to be an anal pyramid of five plates which may belong to this species, and I have been careful to leave it on the specimen, though as the locality abounds in crinoid fragments its mere proximity should not be given undue weight. The apex of the pyramid shows a very small starlike opening, each plate having a more or less pointed tip and failing to meet its neighboring plates near the apex.

Three rings of the stem are still attached to the cup and seem to be rather uniform in size, about four to the millimeter and 1mm in diameter.

This species differs from C. radiatus in its less globular form, the stouter IAx, and the fact that its arms divide above the first free joint.

Collected by Mr Percy E. Raymond.

BRACHIOPODA

Genus SCHIZAMBON Walcott

Schizambon duplicimuratus sp. nov.

Plate 5, figures 6-7

Description. Pedicle valve subcircular, well rounded anteriorly, slightly straightened for about 70° on each side of the small and rather clean cut apex; length of shell 5mm, width 5.4mm; greatest convexity a little to each side of the pedicle opening and raising surface of shell about 1mm above the plane of the shell margin; apex about .5mm above the cardinal margin and slightly projecting over it. Foramen subovate, about .88mm wide, anterior edge 1.8mm from apex, earlier portions filled up leaving a narrow depression with smooth convex floor, narrowing posteriorly and reaching the extreme point of the apex. Surface ornamented with nearly concentric, raised striae which completely encircle the valve; they are single and rather crowded where they cross the cardinal area but are strongly raised and distinctly wider and double over the anterior and lateral regions of the valve. In front of the pedicle opening eight pairs of these striae can be counted in the length of 2.5mm on anterior portion of vertical axis. The spaces between one pair and the next are rather deep and .2mm wide, the distance across each pair is slightly less. The outermost rampart on the double portion bears a fringe of short spines set about .12mm apart.

Brachial valve similarly ornamented but less produced posteriorly along the cardinal margin.

Observations. This species seems to be a little larger than S. typicalis Walcott, and to differ from that species in its relatively larger pedicle opening, its more nearly spheric or transversely oval outline, and in the prominent and double, not lamellose, striae over the anterior and lateral slopes of the shell surface.

Described from three specimens, one of them collected by Mr Percy Raymond and kindly sent me for comparison.

Genus SYNTROPHIA Hall and Clarke

Syntrophia multicosta sp. nov.

Plate 5, figures 8-15

Description. Shell outline semioval, in some specimens inclining toward subquadrate; hinge line straight, usually equal to greatest transverse diameter and in a large specimen measuring 16mm. In such a specimen the length would measure 10.5mm and the distance from hinge line to apex of pedicle valve 8mm. Cardinal angles about 90°, not rounded, sides generally rather straight and parallel for a distance reaching nearly to the ends of the transverse axis; the anterior half of the shell uniformly rounded save for a distinct flattening of the anterior margin.

Pedicle valve with wide flat cardinal area the sides forming an angle of from 95° to 110° at the beak; beak slightly convex; the slope from beak to valve margin quite straight and nearly uniform in all directions. Delthyrium triangular, two thirds as wide at the hinge line as it is high, and reaching apex.

Brachial valve nearly flat with a very shallow sinus, not showing in all specimens.

Radiating costae are numerous and nearly uniform in size from near the point of their origin to their termination on the margin; as shell growth proceeds new costae are added by implantation. Shells about 2.5mm long have some 33 costae, shells of 5mm length have about 49, while adult shells have 81 and over. In figure 13, plate 5, if the two strong costae on either side of the midcosta are traced to their termination on the margin they will be found to have 11 costae between them instead of one. The new costae do not seem to have been added in regular order, for while the new group of five to the right have their middle one the longest, the middle one of the new five on the left is the shortest and youngest. The costae are crossed by fine raised striae, about .25mm apart. In the gerontic stage the additions to the shell margin of the brachial valve tend to add very markedly to its convexity.

The interior of the brachial valve shows a strong and prominent median ridge starting from the middle of the valve and widening

backward till it meets the cruralium. This ridge gives off two lateral branches from its middle portion, equally raised but narrower and pointing toward the ends of the transverse axis. These ridges form the inner boundaries of four deep muscular pits of nearly equal size. The posterior pits with a very slight additional extension backward would leave the cruralium as a narrow platform supported by the wider portion of the median ridge. The two anterior pits are a little nearer together and each shows three distinct muscular impressions separated by two very narrow and slightly raised ridges. The middle scar of each three is the largest, is subtriangular, and has its apex pointing a little inside of the well marked dental sockets; the outer pair are a little smaller, of nearly the same shape and with apex pointing very nearly toward the small, narrow cardinal process; the outer impression of the three is a little smaller still and rather rounded in outline. The pedicle valve bears a wide spondylium well raised from the valve and supported by a fine and narrow median septum which is continued anteriorly to the middle of the valve. The arrangement of the genital and pallial sinuses is shown in plate 5, figures 10, 14. The muscular areas on the spondylium are not distinctly separated but one can distinguish three tracts, a central and two outer of nearly the same area, the boundaries of which are not sharply limited. The delthyrium is bordered by a narrow raised ridge which is continued around the cruralium of the brachial valve. At the apex this well rounded border meets a straight raised ridge tangent to the curve, and just anterior to the ends of this ridge, and outside of the curved border, are two short, narrow, depressed pits usually worn off in most of the valves found.

LAMELLIBRANCHIATA

Genus MODIOLOPSIS Hall

Modiolopsis subquadrilateralis sp. nov.

Plate 4, figures 8, 9

Description. Shell small, from anterior to posterior extremity nearly 9mm. Rather elongate ovate with anterior margin truncate, the straight portion of this margin making an angle of about 125° with the anterior third of the dorsal margin which is also straight;

the beaks are at the angle, and are therefore well forward; the hinge line carries the middle portion of the dorsal line above the flat plane of the umbones and gives the shell a very slightly alate appearance; posterior margin about twice the length of the anterior and quite regularly curved, the sharpest bend being found at the posteroventral margin; ventral margin very slightly convex, a little more straightened in middle portion and forming an angle of about 25° with the general dorsal area as viewed across the shell; the basal line forms an angle with the margin of the anterior truncate part of a little less than 90° and the curve of the basal margin gradually and regularly increases till it meets the margin of the anterior truncate portion in a well rounded angle. Extreme breadth of shell 3mm and at a point but little anterior to the middle and very closely halfway between dorsal and ventral margins. Beaks incurved and nearly touching, byssal pit just below them and the cause, in part, of the truncate appearance. Surface very regularly curved, the usual oblique ridge from beaks to posterior margin not prominently marked. Concentric growth lines very fine and numerous but not easily seen.

Genus CYRTODONTA Billings

Cyrtodonta? lamellosa sp. nov.

Plate 4, figures 10-13

Description. Shell of moderate size, its length being 20.7mm; length of hinge line 10mm; a perpendicular from posterior extremity of hinge line reaches posteroventral angle and measures 16mm. (posterior hight of shell); posterior margin convex and quite closely forming the arc of a circle of 10mm radius with center on axis of greatest length; the arc extended forward would follow the shell for about one fourth of dorsal margin and then enter the shell again at or very close to the beaks; ventral margin but little convex, nearly straight to point directly below beaks, anterior hight 7.7mm; anterior margin at first following the gentle curve of the ventral margin, but becoming markedly convex when it rounds back toward the beaks; the outline of the shell with the exception of the segment cut off by the straight hinge line and the projection of the anterior margin closely resembles the outline of the gibbous moon.

Crescence line diffuse, well curved, slope of surface of shell from this line to either margin gently convex; greatest breadth of shell on this line about one third way from beak to posterior angle and measures 7mm. The surface is lamellose and imbricated, lamellae widen as posterior angle is approached and are there placed with their edges something over 1mm apart; they project from the shell about 1mm or a little more and become crowded on the margin during the gerontic stage.

The valves seem to gape very slightly at the anterior extremity, perhaps indicating a byssal opening. Area crushed in, but posterior extremity of hinge line presents a well formed channel between the winglike posterodorsal extension of the valves, as in Unio alatus, as if to receive a parivincular, opisthodetic ligament. The shell substance is rather thin near the middle of the valve and becomes markedly thicker near the posterior margin.

A line connecting a series of points placed at the successive positions of posterior extremity of shell (measured from the probable position of the beaks) marks also the places of greatest breadth met in crossing the shell and lies over the path of the successive positions of the posterior adductor. A line from apex to posterior extremity of one of the earlier neanic stages, when the shell had attained about one third its length, makes an angle of 30° with the hinge line; during the growth of the remaining two thirds of the shell this line is gradually turned away from the hinge line through an angle of an additional 27°.

GASTROPODA

Genus EUNEMA Salter

Eunema historicum sp. nov.

Plate 4, figure 5

Description. Shell small,[1] turbinate, apical angle 80°, whorls about four. The body whorl shows five well marked minutely tuberculate spiral costae with trace of a faint sixth at the broken edge, well down on the base. The first costa (numbering down from

[1] The type specimen, being broken diagonally across the lower portion of the axis, has lost the aperture while the apex and most of the body whorl are preserved; it has a hight of 4.3mm.

suture) is sharp; the second and third are more raised, prominent, blunt, and each about one fourth as wide as the interspace; the fourth is a little nearer the third, less prominent and narrower; the fifth is nearer the fourth by about half the distance between fourth and third and is about half as wide as the fourth.

Following the outline of a vertical section through the body whorl, the shell is seen to be slightly angulated; from suture to outer edge of first costa the line is straight and at right angles to the axis; a straight line taken from first to third costa would make an angle of about 23° with the axis; the projection of the second costa beyond this line gives a slight convexity to this spiral belt of the whorl; the outer edges of the third, fourth and fifth costae are more nearly in line with each other and this line is nearly parallel with the axis of the shell, its inclination toward the base being but slight; from the fifth rib the surface approaches the axis by another flattened belt, at an angle of about 45°; the final approach to the axis is lost. The intercostal spaces are concave, the amount of concavity increasing markedly as the lower costa is approached, giving a rather horizontal surface to the upper portions of the stronger costae or in certain lights making this upper edge appear slightly reflexed. The suture lies at the base of the nearly vertical, spiral belt or just under the fourth costa and is thus situated at the apex of a clearly cut right angle, two sides of which are formed by the flattened belts already described. The shell is faintly marked with transverse striae the more prominent of which are about 2mm apart; between these a still fainter line can in many places be distinguished; their direction is at first very nearly perpendicular to the suture and on the body whorl they appear to run gently backward from the fourth costa; they are more easily seen above the suture and here seem to be nearly vertical across and beyond the fourth costa; finer growth lines may be detected.

A little more than the first whorl of this specimen is somewhat Natica-like, not angulated, destitute of costae, and the apical angle is more obtuse being about 90°. The transverse striae seem to appear first and are present on the second whorl. The vertical and horizontal flattened belts are present on the third whorl and the first,

second, and third costae are clearly developed; the fourth costa seems to have had a later origin as it is not detected till we reach the later portions of this whorl. The intercostal spaces on the third whorl are more uniform and not so deeply concave; the gradual change to the greater concavity near the lower costa can be easily seen in different portions of the fourth or body whorl.

The name historicum was suggested by the well presented ontogenic series in shell growth.

Eunema epitome sp. nov.

Plate 4, figures 6, 7

Description. Shell small, turbinate, apical angle about 80°, length 10.3mm, whorls about four and one half, upper surfaces a little flattened giving a distinct conical aspect to the upper portion of shell. A well marked keel on periphery and three more of like character between this and the suture; these four keels nearly equidistant and clearly defining the broad, shallow, concave grooves which lie between them. Keel next the suture and distant from it about half the width of one of the grooves, finer and sharper than the others, the second keel from suture strong and rounded and touching the sides of the apical angle. The suture is formed on the peripheral or fourth keel, and the half groove of the body whorl is made to fit the base of the smaller groove of the whorl above in such a manner as to make the suture show as a simple line in the middle of a groove very similar to and but slightly deeper than the others. Base of shell near termination of penultimate whorl nearly flat making an angle of about 90° with upper surface; nearer the aperture the base becomes more convex and a tendency to lose gradually the angle of the penultimate whorl is well marked; the last third of the body whorl is lost but the changes introduced point to a well rounded aperture. There are five revolving keels on base, the three next the columella being the finer and closer together; two new ones with trace of a third are introduced soon after the commencement of the last whorl and are in position still below the three last mentioned. Very fine and obscure transverse striae, about seven

to the millimeter, run backward from the suture and each keeps approximately in the plane of its origin till it terminates on the columella.

Observations. The apical angle of the shell in its two whorl stage is considerably over 100°, and becomes reduced to about 80° on the completion of the third whorl; on certain lines the fourth whorl rather increases this angle and so makes the outline across three whorls from shoulder to shoulder slightly concave. The revolving keels appear in the second whorl.

The earlier portions of the suture are a little more angulated, but acceleration seems to have carried back toward the apex the peculiar feature of making the suture appear as one of the grooves.

The slight flattening of the upper surfaces of the whorls and the very marked obliteration of the suture by turning it into a groove so very like the others may have served to make the shell less readily distinguishable, as such, to the primitive perceptive powers of some important enemies.

The introduction of the new keels and the widening to which they must have been subjected during the probable inflation of the base of the whorl and the rounding of the aperture suggests that the grooving of the upper portion of the whorl was later carried to the base of the last half of the body whorl. This change was probably induced by a changing in the position of the heavier shell during locomotion or rest, and enabled the possessor to still present the peculiar grooved aspect whatever may have been its purpose.

This shell also seems to recapitulate in its ontogeny some interesting features of its very remote history and at the same time, when compared with modern shells, to show quite as remarkable an acceleration as many of these; the name *epitome* therefore is suggested as an appropriate one.

Eunema altisulcatum sp. nov.

Plate 5, figure 3

Description. Shell small, turbinate, pyramidal, apical angle 52°, hight 6mm. Whorls four, uniformly increasing in size, hight and width of body whorl to total hight closely in ratio of 3:5; three

prominent, projecting and clear-cut revolving keels on penultimate whorl, the uppermost of which is the weaker and forms the outer edge of a flat revolving shelf which is depressed at an angle of about 115° from the vertical axis. The edge of this keel is narrow and rather vertical. Just under it a second shelf commences, having about the same width and angle as the first; it is slightly concave and is limited by the second and stronger keel. Under this is a wider, more strongly concave space with its lower border sloping down at an angle of about 45° to the vertical; the limiting keel to this revolving groove is the strongest and most extended of all. The edge of the shell is now cut strongly back, beginning at an angle of about 90° with last surface and curving down to a very fine keel immediately above the suture or reaching the suture itself. The suture thus comes to lie in the widest and deepest revolving channel of the shell. There are five or six fainter revolving keels on the base but the shell is not depressed between them; the three next to the columella are the nearest together. The lip is broken but appears to have been well rounded and to have been slightly extended over the columella at the base of the outer lip so as to leave a very narrow and slitlike cavity appearing like a nearly covered umbilicus. The revolving keels do not begin to show till the latter part of the second whorl. Very fine and faint transverse striae, about 10 to the millimeter, cross the later whorls, and the edges of the keels are slightly roughened or finely nodular.

Collected by Mr Percy E. Raymond.

Genus STRAPAROLLINA Billings

Straparollina harpa sp. nov.

Plate 5, figures 4, 5

Shell very small, turbinate, spire low, hight 2.5mm, width about 4mm, apical angle about 125°. Whorls three, well rounded, rapidly enlarging, crossed by fine raised, laminate ridges, vertical to the surface and about .2mm apart. Umbilicus deep, about one ninth the width of the shell, the lip at the notch extended and partly reflected over it.

Differs from S. asperostriatus Billings in its smaller size, its more depressed spire, its relatively narrower umbilicus, the closeness of its raised striae, and the absence of any carina along the underside.

Described from three specimens collected by Mr Percy E. Raymond.

Genus SUBULITES Conrad

Subulites raymondi sp. nov.

Plate 4, figures 1, 2

Description. Shell small, fusiform; apical angle about 44°; length of specimen, with apical whorl, or a little more, lost, 9.5mm; greatest thickness across axis at middle of shell 3.4mm. Whorls five or six; penultimate whorl showing a rapid elongation, body whorl 6mm long or considerably longer than the spire.

Aperture elongate, oblique, narrow, with well formed anterior canal; inner wall of aperture nearly straight; outer lip convex, gradually increasing its distance from the axis for about one fourth its length, remaining very nearly parallel for another fourth and then slightly increasing its convexity to anterior extremity. With aperture toward the observer, the shell appears slightly angulated at a little above middle on the left, and a short distance below the middle on the right; turned toward the left through 90°, the right hand outline is more uniformly convex. Suture but slightly impressed; surface smooth.

Observations. The shell surface is well preserved and in some lights seems to show growth lines much like those of Terebellum subulatum Lam., to which this species shows a superficial resemblance in its spire, inner wall of aperture, and anterior canal. With other lighting however there seem to be growth lines running gently backward from the suture. These lines are not easily seen and some of them may be due to marks made in cleaning the specimen. Still very faint but more easily seen are some extremely narrow, fine, raised, transverse striae about 4mm apart.

This species has been named after Mr Percy E. Raymond, of the Carnegie Museum, Pittsburg Pa. who found the species in material from the section described.

Genus HOLOPEA Hall

Holopea microclathrata sp. nov.

Plate 4, figures 3, 4

Description. Shell small, turbinate, apical angle about 73°, length of type specimen in which apex and last fourth of body whorl are lost, measured from broken part of apex to most distant point on body whorl 8mm. Whorls about four, becoming gradually more oblique, longest diameter of body whorl near the aperture making an angle of about 50° with the vertical axis. Base of penultimate whorl slightly flattened and making an angle of about 90° with upper surface; angle well rounded and upper surface moderately convex; outline of whorl rapidly becoming more rounded as aperture is approached. Columella apparently strong and thickened and there seems to be a small umbilicus; no trace of lip across wall of aperture. Eight fine revolving, raised striae between suture and periphery; on the penultimate whorl the first, second, fourth, sixth and eighth are the more prominent of these. The spaces before the first and between this and the second are a little wider than the others and are gently concave; the third stria (the first of the fainter or secondary striae) lies at the center of a wider and shallow concave belt limited by the second and fourth striae; after the second the distance between striae is quite uniform and the secondary striae are nearly as prominent as the primary and are but slightly or not at all depressed below them. There is a peripheral stria and eight or more similar striae on base of penultimate and body whorls. The shallow spaces between the striae are crossed by very fine and sharp, raised, transverse striae, as close as 17 or more to the millimeter. These striae pass slightly backward from the suture, curve regularly and gently across the whorl and become directed forward on the base. Viewed from the middle of the whorl the lines appear to make no deviation whatever in any part of their course from the vertical plane of their origin. The suture forms a fine, rather impressed line just below the eighth stria, the whorls meeting at an angle of about 90°.

TRILOBITA

Genus CHEIRURUS Beyrich

Cheirurus mars sp. nov.

Plate 5, figures 1-2

Description. Glabella somewhat resembles a medieval, conical helmet, rising from the frontal rim with a curve of about 6mm radius for one third the distance to the apex of the cone. In the other two thirds the convexity becomes markedly less and the apex is approached with but very slightly convex outlines; from the apex to neck furrow the outline is at first concave and then straight. The cone or spur is thus rather high and produced backward over the neck ring. Length from frontal furrow to neck furrow 13mm, from frontal furrow to apex of cone 15mm, hight of apex of cone above neck furrow about 8mm, width of glabella just in front of the neck ring nearly 12mm. The glabellar furrows are convex toward the front throughout their length; the two anterior pairs reach to a little less than one fourth the distance across the glabella; the middle one is most convex toward the front; the posterior furrow is less bent at first, reaches about halfway to the apex of the cone and is bent so as to meet its axis at an angle of about 70°. Marginal furrow of glabella rounded in front, distinctly angled as it turns to pass along the sides, where it is concave toward the under surface with a radius of about 10mm.

Differs from C. vulcanus Billings, in the pronounced character of the conical spur, the absence of a sigmoid flexure in the posterior pair of glabellar furrows, the shortness of the two anterior pairs, and the front angles of the margin. Described from a cast the surface of which is smooth.

THE STRUCTURE OF SOME PRIMITIVE CEPHALOPODS

BY R. RUEDEMANN

Plates 6–13

Professor Whitfield has described [1886,[1] p. 319], as Orthoceras brainerdi, a cephalopod from the Fort Cassin (Upper Beckmantown) beds of Fort Cassin Vt., which is also very common in beds of like age outcropping along the shore of Lake Champlain at Valcour N. Y. While the originals of the species exhibit but fragments of the phragmocone and lack the living chamber and the apical parts of the conch, there are in the extensive museum collection of specimens secured at Valcour, not only conchs which supplement the original material but also a great number of siphuncles which exhibit interesting internal structures.[2] These and the peculiarities of the apical portion of the conch have led to the investigation, whose results are herewith presented. An extension of the research to the siphuncles of Piloceras explanator Whitfield, another form which is equally common in the Fort Cassin beds at the type locality and at Valcour, has brought to light homologous structures which are also described here.

1 Parts of siphuncle

In a siphuncle of the mature conch of Cameroceras[3] brainerdi four well defined parts, succeeding each other in apertural direction, can be differentiated. For reasons of plainer demonstration we will consider them here in the reversed order of origin or in apical direction. The first portion of the siphuncle of this species is entirely empty, as in Orthoceras [*see*

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[1] See list of references.

[2] Subsequently these structures were also found in specimens from Fort Cassin itself, which are a part of the State Museum collection.

[3] We use here the older term Cameroceras not differentiating between Cameroceras and Endoceras, as Hyatt has done.

pl.6, fig.2]. The septal necks,[1] however, do not as in most orthoceratites extend only a short distance backward, but curve first gently inward, thus contracting the siphuncle slightly and just above the preceding septum bend again outward, growing thicker and standing on the latter septum. The cameras are thus completely shut off from the siphuncular space. There is, however, no separate siphuncular wall present in this part, the septal necks forming the only partitions. The proportional length of this part to the total length of the conch I have not ascertained; it is, however, certain that this open siphuncle extended for the distance of several inches apicad from the living chamber.

Under the second part of the siphuncle we comprise that portion in which the organic deposits characteristic of Cameroceras and consisting of endocones begin to form. The space included by the last formed endocone is a cone with elliptic or more frequently subtriangular section, the base lying parallel to the flat side of the siphuncle [*see* pl.8, fig.7]. The more convex side is provided with low annulations which are slightly convex forward. The cone is always filled with matrix, like the living chamber and open part of the siphuncle and is what Dewitz and other authors have termed the "Spiess" (or dart) of the endoceratites. The last endocone is in sections [*see* pl.9, fig.2] distinctly set off by its darker color from the coarsely crystalline white calcite infilling of the more apical portions of the siphuncle, which suggests that, when left behind by the advancing animal, it contained considerably more organic matter than is found in the solid part of the siphuncle where calcite infiltration has taken place. This endocone connects with a cylindric layer of equally carbonaceous lime carbonate, which being directly adjacent to the septal necks, lines the entire siphuncle and extends forward into the first part to an extent at present not known to me, but certainly not comprising the entire first part, for its absence in the siphuncle for several inches from the base of the living chamber could be ascertained in

[1] We prefer the older term "septal neck" to the later "funnel" proposed by Hyatt for the reason pointed out by Foord [1888, p. 130] that under funnel another organ of the recent Cephalopoda is understood.

several specimens. In the opposite or apical direction it extends close to the tip of the siphuncle. This internal lining layer of the siphuncle will be termed in this paper "endosipholining" [*see* p.303].

The third part of the siphuncle is that which has been filled by the endocones, but is still surrounded by the cameras of the phragmocone. The endocones have mostly become obliterated by the formation of coarse white calcite, but from the endosiphuncular canal there still proceed at intervals short lines which are parallel to the last endocone and represent the bases of former endocones [*see* pl.9, fig.2]. Occasionally also the entire walls appear still as gray lines in the calcite filling [*see* pl.6, fig.3]. The "dart" or "Spiess" extends at its apical end into a flat broad tube, which frequently passes through nearly the whole width of the siphuncle and which possesses strong, deep black walls of velvety appearance, suggesting their composition of conchiolin. This flat tube is the first part of the endosiphuncle.[1] The latter passes through the whole length of the siphuncle. Its characters are such as to invite detailed description, which will be given below.

The fourth part of the siphuncle of this species is that which projects apicad beyond the camerated portion of the shell (the phragmocone), and which, hence, was entirely free. This part is identical with the apical cone of Nanno aulema Clarke and Vaginoceras belemnitiforme Holm. It is, however, not short and strongly inflated, but long and gradually widening at approximately the same rate as the anterior parts of the siphuncle. This free portion may have easily reached a length of 70 mm as the finely preserved specimen reproduced in plate 6, figure 3 indicates.

It might be presumed that in the specimens in hand the septa continued further apicad than their present preservation would indicate, and that the free apical cone is more due to incomplete

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[1]We use here provisionally, till further definitions have been given, Hyatt's term "endosiphuncle" for the central tube of the siphuncle. Hyatt's definition is [1900, p.515]: "Organic deposits in the form of endocones, and taper off at the center into a spire that is sometimes tubular and hollow, or again flattened and elliptical. This is the endosiphuncle." Before this definition the term "endosiphon" had been in use for the same organ.

retention of the phragmocone than to its original absence in the apical portion of the shell. Since however in this species the septa by their septal necks or funnels form a continuous ectosiphuncular wall, which is thicker than the septal partitions and is readily distinguishable in one specimen [*see* pl.6, fig.3] by its light gray color contrasting with the black matrix, we have carefully searched for traces of this wall along the apical cone, without finding any beyond the contraction of the shell at the beginning of the visible chambering of the conch. A black conchiolinous deposit forms the undoubtedly outermost wall of this preseptal conch.

A little forward of the beginning of the cameras (about the fourth camera) there occurs a distinct contraction, as in the corresponding places in the species cited above. The apical portion of this free part is slightly curved. The endosipholining, which in the phragmocone is adjacent to the septal necks, extends through the full length of this apical free part of the siphuncle [*see* pl.3, fig.3]. It contrasts distinctly with the white coarse calcite filling of the siphuncle and retains its full width and sharp delimitation to within 30 mm of the apex, when it begins to thin out; and about 15 mm from the apex it has disappeared entirely, the siphuncle being there wholly filled by the white sugary calcite. The extension and composition of this layer of carbonaceous calcite leaves no doubt that it originally formed within a membrane and thus became charged with organic matter. This endosipholining is in section sharply outlined by a fine black line which represents an outer conchiolinous shell layer. This also extends into the chambered portion of the shell, at least into its earlier part. It is this layer which gives to the separate siphuncles of this species their black, shiny surface. There is no doubt that this is identical with the cuticle of horny matter which incases the whole mantle and also the siphuncle of Nautilus, and which also has occasionally been observed enveloping the siphuncle of fossil cephalopods.

The endosiphuncle passes unrestricted to the very apex of the siphuncle, where it distinctly empties to the exterior [*see* pl.6, fig.3]. Its last apical part (about 1 mm) is filled with black material which appears to be the same as the matrix. This suggests that in this

form, as in Nannoaulema (according to Hyatt's observations) the endosiphuncle communicated for a time with the exterior, viz from the time of the destruction of the protoconch to that of the plugging of the canal between the first and second endocones. At the time of the burial of the shell in mud, this short end of the canal was still open and the surrounding mud could enter it. In the remaining portion of the endosiphuncle there has nowhere been found any matrix, in our material, not even directly behind the Spiess, which is always filled to near its tip with mud. Holm comments on this fact, but states that longitudinal sections through the endosiphuncle nowhere suggested the presence of any transverse partitions and assumes that soft parts of the decaying animal, remaining in the "Spiess" prevented the mud from entering the endosiphuncle, which apparently was through the lifetime of the animal in open connection with the latter.[1] In Nannoaulema however, as mentioned above, Hyatt observed a closing of the tube in front of the first endocone. Partition lines, forming acute angles with the endosiphon, leave no doubt that also the apical cone of Cameroceras brainerdi was provided with endocones though no traces of the same have been observed close to the apex.

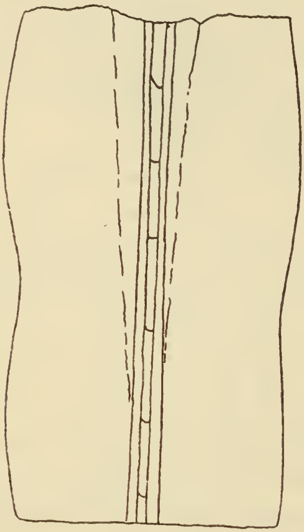

Fig. 1 Endoceras crassisiphonatum Whiteaves. Shows apparent dissepiments in endosiphuncle. (Copy from Whiteaves)

[1] Whiteaves [Roy. Soc. Can. Proc. & Trans. 1891, 9:79] has recorded that in one specimen of Endoceras (E. crassisiphonatum) from the Trenton limestone of Manitoba, "the interior of the narrow posterior end of the siphuncle (endosiphuncle) appears to be portioned off by a few transverse concave dissepiments" [*see* text fig. 1]. Since there exists an early genus (Diphragmoceras *Hyatt*) in which the siphuncle is divided by tabulae alternating with the septa of the camerated shell, it is quite as possible that the endosiphuncle also may have been tabulated in some forms, though Whiteaves's observation seems to stand quite alone at the present time. The observations of both Hyatt and Whiteaves would seem to support Zittel's view that the siphuncle has no particular function but is only a residual.

2 Former observations on endosiphonal structures and the terminology of the latter

The endosiphuncular structures of Cameroceras brainerdi which concern us most here are the flattened tube extending backward from the "Spiess," the fine, often capillary tube extending the greater length of the siphuncle and certain thin longitudinal layers of dark organic limestone radiating from these tubes to the walls of the siphuncle.

The attention of paleontologists was directed to similar structures only a comparatively short time ago, though the fine threadlike endosiphuncle had already been noticed by Barrande in a Newfoundland species (Orthoceras insulare) [*see* 1867, v.II, t.430, fig.5, 8-11; t.431, fig.8-10] and also been described by Dewitz [1879, p.172, 173, fide Holm] and Schröder [1881, p.76, t.2, fig.8d]. Dewitz also mentions [1880, p.377] that "in some species membranes seem to have proceeded from the posterior end of the fleshy siphuncle, which often, at least for some distance, extended to the internal wall of the siphuncular tube, and which also secreted covering sheaths, in which organic carbonate of lime was deposited," and adds, "These membranes probably served to attach the posterior end of the fleshy siphuncle to the interior wall of the siphuncular tube." He also figures a transverse section of Endoceras commune [pl.17, fig.7] which shows three longitudinal membranes radiating from the endosiphuncle, but which do not reach the siphuncular wall [*see* text fig.2].

Fig. 2 "Endoceras commune." Section of siphuncle. s, siphuncular side; a s, antisiphuncular side. (Copy from Dewitz)

The flattened tube extending from the "Spiess" appears to have been first noticed by Dawson in a species of Piloceras [1883, p.4]. Sir William states [p.3] that "the lower part of the shell is divided by a vertical partition crossing its longer diameter," and again [p.4] that the internal cone "is flatter than the siphuncle, ending at the apex in an edge which is attached to a central shelly plate crossing the lower part of the

siphuncle," and adds, "This plate shows at intervals slight projections giving rise to delicate cones apparently membranous." Hyatt [1884, p.266], though basing his definition of Piloceras on Dawson's description, did not recognize the presence of a partition, but believing in its tubular character, referred it to the endosiphuncle. Foord, however, observed again the same plate in a Piloceras from Durness and figured it [1888, p.159, fig.17, III, p.160], stating in regard to it in opposition to Hyatt's view: "Nevertheless there seems to have been an internal septum extending upwards, from the lower part of the siphuncle, between the wall of the latter and that of the sheath into which the endosiphon opens. This septum shows itself in some transverse sections of the siphuncle in the manner indicated at figure 17, II [copied here in text fig.3], and it can be traced for some distance upwards in the vertical section of this and of other specimens. The septum seems to have been penetrated by the endosiphon, as shown in the figure, but I am unable to give any satisfactory account of it, owing to its imperfect condition." Bather later [1894, p.433] copied Foord's figure, stating that the appearance of the partition is exaggerated and its significance unknown. Specimens of Piloceras explanator from the Fort Cassin bed, which are in the State Museum, show the same partition and we shall have occasion to recur to its structure [*see* p.329].

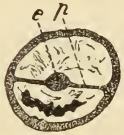

Fig. 3 Piloceras sp. Transverse section of siphuncle. e, endosiphuncle; p, partition. (Copy from Foord)

Meanwhile Holm had found a similar endosiphuncular blade strongly developed in a species from Esthonia, which he described in allusion to this feature as Endoceras gladius [1887, p.13]. In this important publication, to which we shall have frequent occasion to refer, Dewitz's observation of the winglike membranes of the endosiphuncle, is verified.

In a later publication [1895, p.605ff] the same author has introduced a number of terms for the parts of the siphuncle in view of the fact that Bather had criticized Hyatt's term "endosiphon" [*l. c.*, p.433] arguing that the "endosiphon" is in func-

tion the real siphuncle. As Foord [1888, p.132] has pointed out "exception might perhaps be taken to this term on the ground that it seems to imply the existence of two siphuncles, an inner and an outer one." Since, however, it will be found convenient to distinguish the fleshy siphuncle from the shelly wall that separates it from the septal chamber, and the term siphuncle has always been used in the latter sense in relation to fossils, he considers the employment of the additional term justifiable. To avoid its illogical and confusing use Holm has proposed a series of terms which it seems practicable to adopt here. These are "ectosipho" for the outer siphuncular tube—"sipho" being retained for the entire organ—"endosipho" for the contents of the ectosipho as a whole;[1] also for the parts of the endosipho are proposed new expressions. He terms "endosiphocylinder" the wider portion of the siphuncle, which is entirely occupied by the more cylindric anterior part of the fleshy siphuncle. This passes posteriorly into the "endosiphocone" (its walls are Hyatt's "endocones"); from this again proceeds the narrow canal which was termed first "endosiphon" and later "endosiphuncle" by Hyatt and for which is proposed the word "endosiphotube" by Holm [*see* text fig.18]. We have, in accordance with this terminology, proposed above the term "endosipholining" for the inner, thick, continuous layer of the siphuncular wall, which, according to Hyatt [1884, p.266], is characteristic of Cameroceras (Sannionites) in distinction from Vaginoceras and Endoceras. This layer is shown in plate 6, figure 3 and text figure 15 (*e s c*) and the sections on plate 7. To the endosiphuncular formation belong further thin, calcified membranes which connect the endosiphotubes and endosiphocones with the ectosiphuncle, and a broad conchiolinous double blade, extending backward from the endosiphocone.

The latter structure was originally termed by Holm, who was

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[1] Following Hyatt in making a strict distinction between the fleshy "siphon" and its calcareous covers, the "siphuncle," we will employ here the terms "estosiphuncle" and "endosiphuncle." This usage will not vitiate the terms "endosiphocylinder" etc. in which only the radicle of the word siphon is incorporated; nor will it cause confusion since for the organ termed "endosiphuncle" by Hyatt, a new term is proposed.

the first to clearly recognize it, "schwertähnliches Blatt" [1887]. Later [1895] the same author introduced the term "endosiphoblade" ("endosiphobladet" in the Swedish original) and defined it as the thin calcified endosiphuncular membrane which extends longitudinally in several species of Endoceras and Piloceras and connects the endosiphotube and endosiphocone with the inside of the ectosiphuncle. It becomes evident from the discussion of this organ in the last cited publication that this term is meant to comprise both the hollow blade and the calcified suspensory membranes.

Since we shall show in this paper that the endosiphotube is a new formation, at least in our species, within the broad hollow endosiphuncular part, first called "schwertähnliches Blatt" by Holm, and also that the latter and the suspending membranes are of different origin in our form, it becomes desirable to distinguish between these two organs which are comprised in Holm's term "endosiphoblade." We will therefore, in view of Holm's definition, retain this latter term for the suspensory membranes and designate the broad and originally hollow endosiphuncular "Blatt" by a new term.

Holm named the species, in which he observed it, Endoceras gladius in allusion to this swordlike blade. "Gladius" would therefore be an appropriate term, were it not for the fact that this word is already used for the cuttlebone or pen of the cuttlefish. For this reason we shall use here instead the word "coleon," and to make it conform with the other terms, call this flattened tube the "endosiphocoleon." As "endosiphosheaths" we designate the walls of the funnel-shaped endosiphocones (Hyatt's "endocones"), which are left behind by the advancing animal.

3 Endosiphocoleon and endosiphotube

As we have noted above, Holm was the first to observe, in a species obtained in Esthonia from a transitional bed between the Vaginatenkalk and Echinosphaeritenkalk, the organ which we have found still more peculiarly developed in an American species

and designated as endosiphocoleon. Holm termed the species at the time, Endoceras gladius, but he later [1896, p.400] reunited it with Endoceras (Nanno) belemnitiforme. This again has been referred to Vaginoceras by Hyatt [1895, p.9]. We will state on this occasion that while we had worked out the characters of the endosiphuncular organs before we were aware of Holm's prior elaborate description, we found by subsequent comparison that our material on the whole verifies Holm's observations for the species in hand, but that at the same time it indicates an origin of the endosiphotube and a relation between endosiphotube and endosiphocoleon which is different from those observed by Holm. These and such other differences as have become apparent between the endosiphuncular structures of Vaginoceras belemnitiforme and Cameroceras brainerdi will be noted at the end of the description of these structures in our species. We have copied here for comparison Holm's figure of the endosiphocoleon [text fig.4].

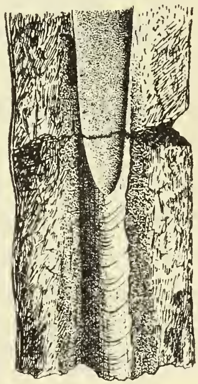

Fig. 4 Vaginoceras belemnitiforme Holm (sp.). Longitudinal section of siphuncle, showing endosiphocoleon. (Copy from Holm)

The endosiphocone which, at its forward end, is subcircular and only slightly flattened on the ventral (outer) side, becomes rapidly flattened toward its posterior end, the convex wall approaching the opposite flat one. It thus runs out into a double blade, which, lying approximately in the middle of the siphuncle and parallel to its flatter side, is at first almost as wide as the siphuncle and nearly touches its walls [*see* pl.7, fig.1]. This is at least the case in the large siphuncle of the later portions of the shell when the animal approaches maturity. This organ is the *endosiphocoleon,* which in our material consists just behind the endosiphocone of two thin, intensely black conchiolinous walls, forming a flattened broad tube. These walls are composed of extremely thin, concentric or rather long conical lamellae. They show a double sculpture, viz, low transverse ribs arching slightly forward and longitudinal lines

which slightly disperse in a forward direction. The low ribs are evidently the remains of the ribs of the convex side of the endosiphocone, noted below.

Holm describes the middle portion of the endosiphocoleon which proceeds from the apex of the endosiphocone as possessing a very distinct and beautiful sculpture, consisting of growth lines. "These growth lines form an arch, which is strongly bent backward. Their form and curvature corresponds exactly with the outline of the apex of the 'Spiess' and thereby with the outline of the fleshy end of the siphon. On the anterior portion of the blade there also occur longitudinal lines which intersect the growth lines." Our material fails to show these growth lines so distinctly, but from the fracture lines of the oblique lamellae composing the wall of the endosiphocoleon we infer that they may be the intersections of these lamellae with its surface.

This middle part of the endosiphocoleon is on both narrow edges [*see* pl.7, fig.1; pl.9, fig.1; text fig.14] flanked by strong deep black conchiolinous semicylindric rods or wings, [w of figures] which, on the upper and lower side of the blade, quite abruptly change into a layer of dark gray limestone, such as composes the endosiphocone or last endocone. They correspond to the winglike lamellae, which according to Holm begin on the endosiphocone and continue along the endosiphocoleon and which we shall discuss later.

The further development of the endosiphocoleon can be best described by the use of a series of sections which were made apicad of the part of the endosiphocoleon reproduced on plate 7. These sections are figured on the same plate and diagrammatic sketches illustrating the further stages of development are inserted in the text [fig.5-12].

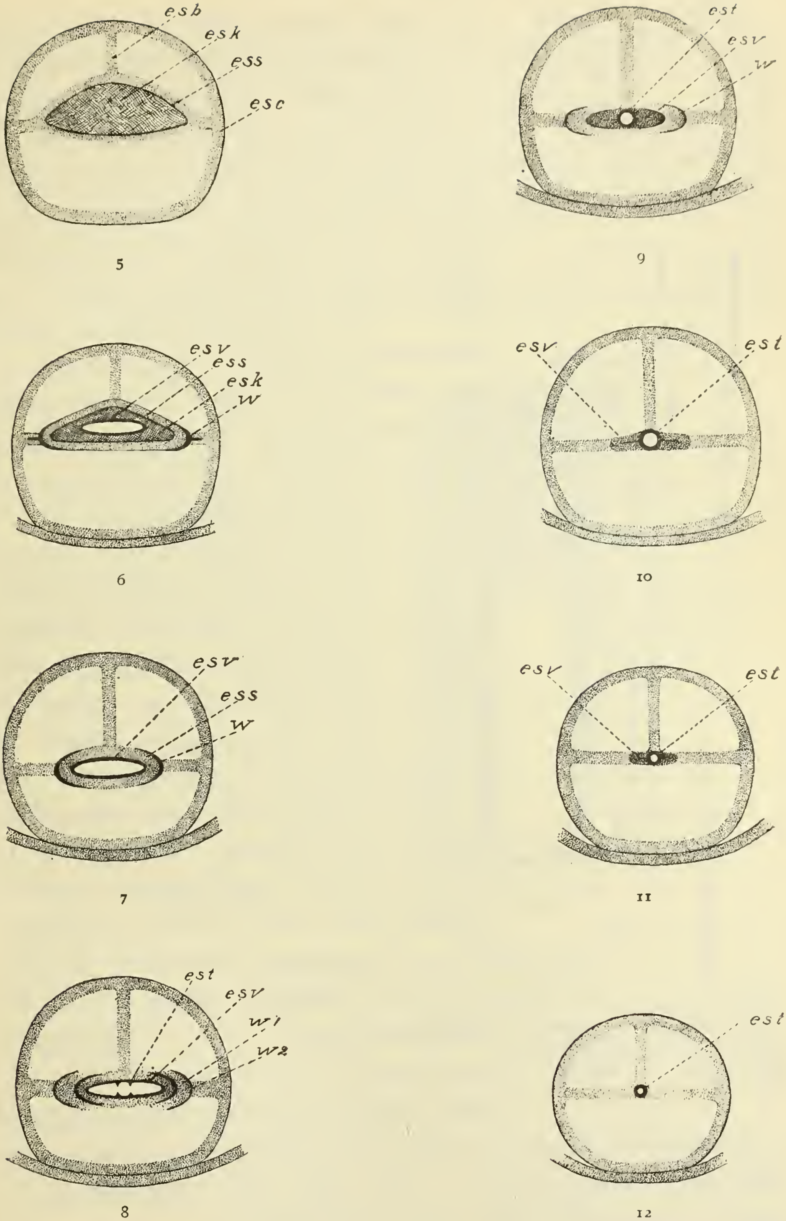

Fig. 5-12 Diagrammatic sections of siphuncle of Cameroceras brainerdi Whitfield (sp.); *e s b*, endosiphoblade; *e s c*, endosiphocylinder; *e s k*, endosiphocone; *e s s*, endosiphosheath; *e s t*, endosiphotube; *e s v*, endosiphocoleon; *w*, wing; w_1, younger wing; w_2, older wing. In figure 11, the endosiphocoleon is shaded too dark.

Figure 5 of plate 7 [also text fig.10] shows the small, thick walled endosiphotube [*e s t*] contained within the endosiphocoleon [*e s v*], which is entirely filled with very dark organic carbonate of lime. This observation suggests that the endosiphotube is not a narrower apicad continuation of the endosiphocoleon, but a new formation within the same; an inference which is borne out by the observation of such sections as that reproduced in figure 2, in which a still incomplete tube is shown within the open lumen of the endosiphocoleon. This latter stage is also represented by the diagrammatic section text figure 8. Besides the inceptive endosiphotube [*e s t*] and the inclosing endosiphocoleon [*e s v*] we see the latter flanked on either side by a series of two wings [w_1 and w_2] which have formed on two successive endosiphosheaths. In text figure 9 only one of these wings, the outer and older is present. In order to make this peculiar relation of endosiphocoleon and endosiphotube still clearer we have added two longitudinal diagrammatic sections. Text figure 13 shows the outer, more anteriorly situated endosiphocoleon and the inner endosiphotube, and text figure 14 illustrates the position of the successive wings [*w*] on the endosiphoshaths [*e s s*]. A condition as that illustrated in text figure 8, when two wings embrace each other could be obtained by a transverse section in a plane, laid through the middle of the longitudinal section figure 14. We shall recur more fully to the relation of endosiphocoleon and endosiphotube.

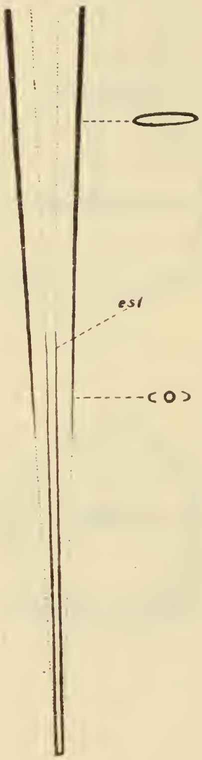

Fig. 13 Diagrammatic longitudinal section of endosiphocoleon, to show its relation to endosiphotube *est*, endosiphotube

Figure 3 of plate 7 is a section 5 mm distant from figure 1.

Between figure 3 and figure 5 (10 mm) a very abrupt quarter turn of the entire endosiphocoleon takes place, so that its hori-

zontal position has changed to a vertical one. A horizontal section through the block containing this turn has been made and the rock polished down sufficiently to expose the turn [fig.4]. Figure 5 shows the front of the next block, which is identical with the posterior section of figure 4. Here the endosiphuncle has become a very narrow cylindric tube (endosiphotube) sharply limited by a black conchiolinous wall. It lies somewhat laterally to a broad, dark gray brown belt of organic lime carbonate, through which the walls of the large crystals of the siphuncle filling pass, though retaining the organic coloring matter in its original distribution. A split is noticeable in the upper part, as if the band here consisted of two lamellae. Text figure 10 represents this condition of the endosiphuncle. The endosiphotube is now the only remaining organ with distinct conchiolinous walls and the endosiphocoleon is reduced to a dark band of organic lime carbonate, a transverse median line of which indicates its former composition of two amellae.

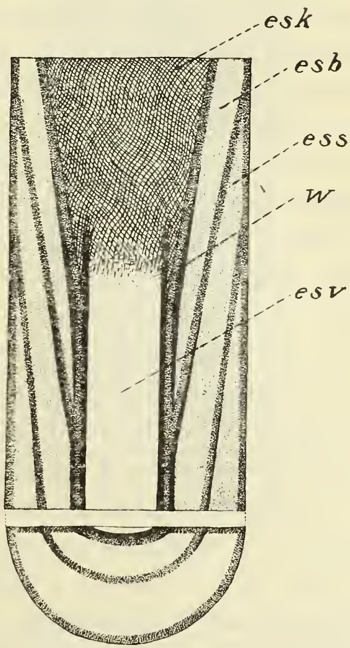

Fig. 14 Diagrammatic section of siphuncle to show the relation of the wings [*w*] to the endosiphosheaths [*ess*]. Endosiphocoleon cut through major axis

On the other side of the block [fig.6, 7.5 mm farther posteriorly] the endosiphotube has retained the same diameter as in the preceding section, though its shape has changed from circular to semicylindric; the endosiphocoleon has not diminished in size, but has become considerably lighter in color and more indistinct in outline, specially in the middle part, while the ends have remained colored slightly stronger and are wider so that the section assumes somewhat the shape of a dumb-bell. The median line, observed in the preceding section, has disappeared, but there remain two darker spots in the center of the end balls

of the dumb-bell. This dumb-bell-like outline is again obliterated in the next section, figure 7 (7.5 mm distant from 6). In this the endosiphotube has again decreased since the last section to about one half of its former diameter, while the endosiphocoleon has retained its width. In the next it has even again become broader. Its ends are notably rounder and thicker than the middle of the plate and a fine central line can again be traced, indicating the composition of the blade of two conjoined lamellae. The entire endosiphocoleon, which before had swung to one side, has returned again to the median line of the siphuncle.

In this condition the endosiphocoleon remains to the apical end of this (not complete) siphuncle, i. e. it extends across the siphuncle as a dark gray brown band with indistinct outline which includes the fine endosiphotube; its swollen lateral extremities touching or coalescing with the gray wall of the siphuncle. Figure 10 is taken 15 mm from the preceding section and shows no material change from the latter. It shows white cross-lines which transect the brown band of the endosiphocoleon. These are due to secondary crystallization, the endosiphocoleon being—in contrast to the irregular crystallization of the remainder of the interior of the siphuncle—composed of two layers of parallel crystals which distinctly grew from the median line of the endosiphocoleon as a base.

Text figure 11 shows the position and extension of the endosiphocoleon in a very early portion of the siphuncle or near the apex [*see* fig. 7]. It is here a light brown transverse band with a central black conchiolinous endosiphotube. This condition is reached shortly behind the endosiphocone in the earlier portions of the siphuncle, when its diameter is still small as is exemplified by the section [pl.8, fig.1].

In order to obtain a complete portrayal of the endosiphocoleon and endosiphocone of Cameroceras brainerdi we will add the description of a few other sections which show features slightly different from or explanatory of those observed in the series of sections noted above. There is, first, the longitudinal section [pl.9, fig.2] in which a well preserved endosiphocone with sheath is exhibited which at its apex contains a newly

formed portion of the endosiphocoleon as a free standing black and conchiolinous tube[1] [*see* text fig.15]. This shows that here the endosiphocoleon is not a mere continuation of the apex of the endosiphocone, as it was found in Vaginoceras belemnitiforme but a new formation, growing within the apical part of the visceral cone, presumably preparatory to a succeeding withdrawal of the animal from that part of the siphuncle and the formation of a new endosiphosheath.

Two sections which exhibit the same features are those reproduced in plate 7, figure 1 and plate 9, figure 1. These possess on both narrow sides of the endosiphocoleon a series of two black concentric crescents which are not in contact with it. In some of these specimens [pl.7, fig.1] the innermost of these crescents can be directly traced along the longitudinal sections to the strong conchiolinous wing or lateral staff of the endosiphosheath described above [*see* text fig.14].

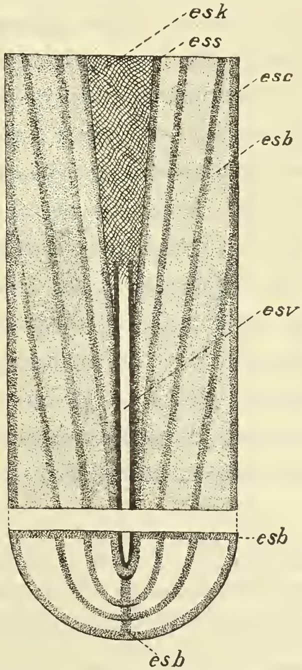

Fig. 15 Diagrammatic section of siphuncle to show relation of endosiphocoleon [*esv*] to endosiphocone [*esk*]. Endosiphocone cut through minor axis: *esb*, endosiphoblade; *esc*, endosipholining; *ess*, endosiphosheath

Directly germane to the sections and diagrams given here and illustrative of the formation and characters of the wings of the endosiphocoleon is the section in plate 8, figure 7. In this the apical part of the endosiphocone is transected and its semicircular outline shown in the center of the figure and its base, which corresponds to the flat or outer (ventral?) side of the siphuncle, is drawn out into short, obliquely ascending horns. The wall of the cone is formed by the endosiphosheath which is continued in the direction of the horns to the wall of the siphuncle and

[1] It is twice as long as the lithographer's reproduction.

also connected at its convex side to the nearest wall by a band of crystals of organic carbonate of lime. The interspaces are not only arranged symmetrically, but also delimited so sharply by uninterrupted lines, that it is hardly to be doubted that the calcite bands connecting the endosiphocone and wall of siphuncle are the remains of the membranes which held the visceral cone in position within the siphuncle and probably became partially calcified during the lifetime of the animal. The interspaces remained cavities till they were filled by the large calcite crystals now occupying the siphuncle.[1]

The supposition of the fixation of the visceral cone and inclosing endosiphosheath to the ectosiphuncle, finds support in the occasional presence of bands of gray brown limestone, extending from the endosiphocoleon (virtually the continuation of the visceral cone) or more posteriorly from the endosiphotube, to the wall of the siphuncle. Such a section is reproduced in plate 8, figure 5. The horizontal transverse band with the inclosed endosiphotube is evidently the "endosiphoblade" of Holm. This is held in a manner corresponding to the fixation of the endosiphocone described above by a band that is placed perpendicular to the endosiphocoleon.[2] The extension of the internal space of the visceral sac (endosiphocone)

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[1]In this particular siphuncle the interior is 20 mm from the end of the endosiphocone already so calcified, apparently by secondary calcification, that hardly any trace of the endosiphocoleon is left [*see* pl.8, fig.8].

[2]These supporting membranes were, as we have mentioned above, recognized by Dewitz and more fully described by Holm. The latter author [*l. c.*, 1887, p.16] sums up his observations on these supporting membranes in Endoceras gladius in the following statement: "During the retrogression of the siphon in the siphuncular tube there were secreted by the siphon three longitudinal membranes which were probably soft, pliable and extended to the wall of the siphuncular tube, one from each of the angular marginal edges and one from the median line of the convex side. Their function was probably to fix the end of the siphon, which was suspended in the siphuncular tube in a position in the middle of the latter. A similar organ was, as we have seen above, observed by Dewitz in the siphuncular tube of a specimen of "Endoceras commune." In consequence of this structure the "Spiess" maintains in all specimens of the species in question, which have been investigated by me, the same position in the middle of the siphuncular tube and indicates an invariable position of the end of the siphon. The thin (cuticular) membranes were secreted along the whole length of the siphon."

into the angles [pl.8, fig.7] and the continuation of the angles into the supporting membranes indicate that the latter already supported the visceral cone before the formation of the last endosiphosheath, determined the form of the latter and at the time of its formation probably became the situs of organic deposits of lime carbonate. This latter view is at least suggested by the presence of cavities between the well defined bands of lime in the section.

If these membranes served as suspensory organs of the visceral cone and its posterior extension, their arrangement will give us a hint as to which side of this Cameroceras conch was the ventral side or turned habitually downward in the moving animal, the position of the siphuncle on one side of the conch not being a reliable criterion on account of its shifting sometimes in the same individual. It will now be noticed that in the sections reproduced in plate 8, figures 5, 6, the tube is suspended by three membranes, two of which form a diameter of the siphuncle, parallel to its flat side, while the third holds a perpendicular position to this diameter and connects the tube with the side of the siphuncle diametrically opposite to its flat side. If now a tube is suspended by means of three membranes, forming an inverted **T**, it is evident that the middle was the upper one. The alternative possibility that the tube was held by props or propping blades instead of by membranes, in which case the relation of the three blades would be inverted, may be neglected on account of the evident thinness and frailty of the supporting organs. It then follows that the flat side of the siphuncle which is in contact with the conch was the lower or ventral side.

4 Comparison of endosiphuncular structures in Vaginoceras belemnitiforme and Cameroceras brainerdi

Holm's elaborate description of the endosiphocoleon of Vaginoceras (gladius) belemnitiforme permits a close comparison of the development of this organ in the Swedish type and in this American form.

In the description of the endosiphocoleon of V. belemnitiforme a distinction [*l. c.*, p.14] is made between the lateral and

middle parts of the " Blatt." The former are described as being a continuation of the two winglike lamellae that flank the endosiphosheath and the latter, which is characterized by its sculpture, as a continuation of the middle part of this endosiphosheath. This difference is in our material, if anything, still more apparent, and the two parts are entirely separated owing to their different places of origin. The wings are formed on the outside of the endosiphocone, while the middle part, which is the real tube of the endosiphocoleon, is formed within the endosiphocone [*see* text fig.14]. The two conchiolinous bodies are hence in Cameroceras brainerdi separated by a layer of gray organic lime carbonate, the endosiphosheath [*see* pl.9, fig.1 and text fig.14]. It is, however, apparent that in V. belemnitiforme both parts are considered as having originated on the outside of the endosiphocone or to be the direct continuations of the endosiphosheath, and the figure [*see* text fig.4] would seem to bear out this conclusion.

Germane to this observation of Holm as to the origin of the middle part of the endosiphocoleon is the further observation and resultant conclusion which is cited here [*l. c.*, p.15, translation]: " With the exception of the conchiolinous calcareous sheath covering the endosiphocone itself, there occur no traces of such sheaths secreted by the siphon, within the siphuncular tube. Neither does the calcareous filling show any conical surfaces of separation. Since, moreover, the lamellae of the swordlike structure which proceeds from the endosiphocone form a direct, uninterrupted continuation of the sheath of the siphon it must be assumed that the siphon did not secrete the conchiolinous calcareous sheath until the animal was full grown and no longer enlarged its conch nor advanced in the siphuncular tube." This blade in V. belemnitiforme is supposed to have reached to the apical end of the siphuncle.

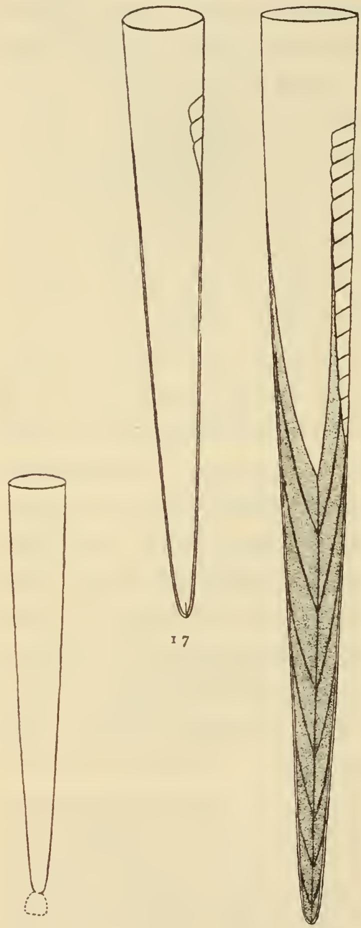
Our observations would indicate somewhat different relations in C. brainerdi. First the presence in transverse sections of a series of embracing crescentic conchiolinous sheaths [*see* pl.7, fig.1 and text fig.8], which are the remains of the winglike

lamellae formed on the outside of the endosiphocones, demonstrates that the wings were formed *successively* on the acute edges of the flattened posterior part of each new endosiphocone [*see* text fig.14], thus leaving with advancing growth and the formation of new embracing endosiphosheaths this series of conchiolinous margins behind. As to the middle portion of the endosiphocoleon we have shown that in our species this is formed within the apical portion of the endosiphocone or visceral cone and is hence always surrounded by the endosiphosheath. The fact of the presence of the anterior portion of this endosiphocoleon within the endosiphocone indicates, in our opinion, that it kept growing continuously at its anterior end and during a greater part of the lifetime of the animal (probably from the beginning of the nepionic stage to that of the ephebic stage); this growth within the endosiphocone being preparative of an approaching withdrawal of the animal and the subsequent formation of a new endosiphosheath. The very gradual disappearance in our specimens of the endosiphocoleon posteriorly by a replacement of the conchiolinous material by organic lime carbonate, without a notable diminution in width, is taken by us as a further argument of the gradual formation at the anterior end of the organ and a corresponding gradual absorption posteriorly [*see* text fig.13]. With this gradual absorption of the posterior endosiphocoleon went hand in hand the new formation of the almost capillary but strong walled endosiphotube.

While we thus hold that in the species in question the formation of the endosiphocoleon was not delayed till maturity, but took place during the entire ephebic stage, we are quite convinced that maturity with its cessation of siphuncular growth and advance of the animal led to a longer continued secretion of conchiolinous matter at the posterior parts of the visceral cone and in the anterior part of the endosiphocoleon, thus producing the thick conchiolinous deposit observed in such specimens where the siphuncle has attained approximately its maximal width, while in siphuncles of still small diameter these same parts, even close to the endosiphocone, are provided with much thinner walls.

Holm subsequently [1895, 17:616; 1896, 18:406] added observations on V. belemnitiforme without, however, recurring to his description of the endosiphuncular structure of the Esthonian material of Endoceras gladius. He states, however, that the latter showed that structure "remarkably well developed and preserved" [*l. c.*, p.617] and that also in Swedish specimens of V. belemnitiforme (=gladius) the endosiphoblade could be observed.

The distinction apparent in our material between the narrow endosiphotube and the wider endosiphocoleon, which in apicad direction becomes a compressed blade, has not been noticed in the European material and consequently Holm's term "endosiphoblade" comprised both the apical blade-like continuation of the endosiphocoleon and the thinner membranes which connect this and the ectosiphuncle.



16 17 18

Fig. 16–18 Diagrammatic sections of early growth stages of shell of Cameroceras brainerdi

5 Growth stages of shell

The description of the transverse and longitudinal sections through the endosiphuncular structures in their various stages of development enables us now to portray the processes which took place within the siphuncle of Cameroceras brainerdi during the animal's advance from the apical cone to the living chamber at maturity.

The *protoconch* or earliest embryonic stage is not preserved.[1] Its former presence outside of the initial apical cone of the shell is clearly indicated by the perforation of the apical end and the opening of the endosiphotube.

The growth stages of the animal of C. brainerdi, as recognized in the shells, are characterized by the successive forming of the apical cone, of the chambered portion, the filling of the siphuncle and the formation of the final endosiphosheath [*see* text fig.16-18]. The shell (protoconch) in which the embryonic stage was passed has not been preserved. The first shell which could be preserved was an open small cup which grew out into a long cigar-shaped open conch, the preseptal or apical cone, or *nepionic bulb* of Hyatt [*see* text fig.16, 19]. It was originally entirely filled by the animal and its wall consisted only of the present outer conchiolinous periderm. The aseptate stage is in Nanno termed the *ananepionic* stage by Hyatt. In C. brainerdi it must have extended through a considerable period of the life of the animal if we can use the length of the preseptal cone as an indicator of the lapse of time.

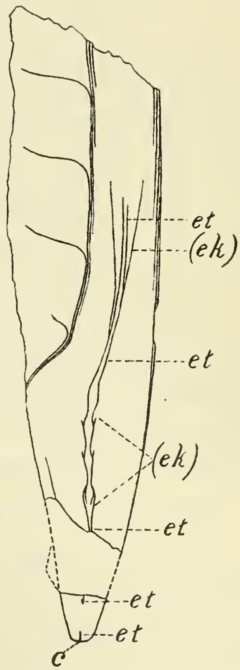


Fig. 19 Vaginoceras belemnitiforme Holm (sp.) Section of apical part showing the nepionic bulb, first cameras, cicatrix [*c*], endosiphotube [*et*] remains of endosiphosheaths [*ek*] and long septal necks, characteristic of Vaginoceras

The *metanepionic* substage in Nanno is characterized by Hyatt as that with septa and a huge empty siphuncle, while the *paranepionic* stage is that with the first endocone and an endosiphuncle formed at the apex. The formation of the first cameras in Vaginoceras belem-

[1]Several authors have at first considered the large apical cone of Nanno aulema and of Vaginoceras belemnitiforme as a protoconch. But the finding of the opening of the endosiphotube at the apical end in both species and of a cicatrix at this opening in the closely related Piloceras (by Foord) leave no doubt that the protoconch in these forms has not been capable of preservation.

n i t i f o r m e has been well depicted by Holm [*l. c.*, p.6, 7] and that of the endosiphosheaths by Bather. We therefore take the liberty of quoting from both of these authors.

The first of these (cameras) originated in this way: On one side of the upper portion of the visceral sac a circular and almost inclosed constriction was produced. The fold of the mantle thus formed deposited shell matter making an inclined wall and a division of a part of the originally open initial chamber. The resulting chamber was empty and formed the first air chamber. The chamber is, thus, bounded by only one septum and in this case lies behind the wall corresponding to the first septum in Nautilus. It therefore corresponds to the initial chamber in that genus. As it here has the same function as the other air chambers, I have termed it the first air chamber, although in fact it is a remnant of the open initial chamber. Moreover, the second air chamber is probably formed in part from the anterior portion of the initial chamber. The visceral sac of the animal was now divided by a constriction into an anterior and posterior portion. . . The anterior portion now forms the actual habitation chamber, but the great visceral sac also fills the posterior portion. *Holm*

This writer describes further how, by the formation of more cameras, the siphonal cord of the animal originates, and concludes: "Hence the siphon of E n d o c e r a s b e l e m n i t i f o r m e must have had its origin in a differentiation of the visceral sac." This differentiation of the visceral sac by the formation of several cameras also took place in C. b r a i n e r d i [*see* pl.6, fig.3 and text fig.17] and may be taken as denoting the metanepionic stage. Whether the cameras were formed for the purpose of supplying a hydrostatic apparatus to the ever heavier growing animal, as Holm assumes, or whether they served simply the purpose of shutting off space no longer used within the conch by the animal which now grew rapidly forward and expanded laterally, is here immaterial.[1]

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[1]The possibility of a different function of the cameras from that of having been air chambers has been asserted by Jaekel [*see* Zeitschr. d. deutsch. geol. Gesellsch. 1902. p.67] and discussed by the writer in a review of Jaekel's paper [Am. Geol. 1903. 31:199].

After the formation of several cameras the animal began to withdraw also from the apical conch and then the formation of the endosiphosheaths set in, which continued throughout the neanic or adolescent age. Bather has described this process so graphically [1894, p.433] that we can do no better than quote here from him.

We know that in Nautilus and Spirula after the secretion of the septal necks, the outer coat of the siphuncle, both inside and outside the region of the septal neck, becomes hardened by calcium carbonate; this gives it a certain rigidity and assists its retention in the fossil state. The same thing must have occurred in the coat of the visceral cone. Now in Piloceras, when the animal advanced in the shell its viscera naturally followed it, and by suction the walls of the visceral cone were drawn in so as to form the narrow and empty siphuncle. At least such would have been the case had not the stiffness of the outer coat prevented complete yielding of the skin, especially at the posterior part where the siphuncle tended to begin, but where the coat was most calcified. It must therefore have happened that the inner layers of the skin were gradually torn away from the outer layers. Another stiffening of the skin would take place higher up and the process would be repeated.

As an explanation of this periodical sloughing it is suggested that the actual moment of the casting "was after the emission of the generative products, when the visceral cone was flaccid; this explanation coincides with Seeley's explanation of the origin of septation itself, but it is not exposed to the objections brought against the latter."

Perhaps the fact that the cast of the visceral cone preserved by the mud filling of the "Spiess" within the last endosiphosheath is sometimes of an undulating character, as in the specimen reproduced in plate 8, figure 3, and at other times well expanded and smooth, thus indicating considerable difference in the relative tension of the wall of the visceral cone, can also be taken to point to the conclusion that the visceral cone, which in our form undoubtedly expanded far back into the siphuncular tube,

served principally as the receptacle for the generative organs, which in Nautilus are situated in the posterior part of the visceral sac.

Hyatt determines the close of the nepionic age in Nanno aulema with the formation of the first endosiphosheath, after which in that form the endosiphotube becomes plugged and thus the open connection closed with the embryo bag or if the latter had been already destroyed, that with the outside. We have no evidence that such a process took place in C. brainerdi after the formation of the first endosiphosheath though here also the matrix did not enter deeper from the outside into the endosiphotube than the thickness of one or a few endosiphosheaths, but it seems to us that the nepionic stage could not be well considered as ended till the nepionic bulb or preseptal cone had been entirely left by the visceral sac of the animal or, in other words, had become filled with endosiphosheaths.

The tube passing through this first endosiphosheath is still both endosiphotube and endosiphocoleon, the differentiation between these two not yet having taken place. Where and when they become differentiated I am not prepared to say. But this differentiation is clearly consequent on the widening of the siphuncle. The latter, as nepionic bulb has only a diameter of 2 mm at the perforation of the first endosiphosheath; it increases to about 10 mm where the formation of the septa begins, measures 15 mm where the endosiphocoleon is fully developed [pl.7, fig.10] and 20 to 25 mm at its passage into the living chamber of a mature individual. With the increase of the diameter of the siphuncle that of the major diameter of the endosiphocoleon apparently keeps pace. Since, however, as the animal removes itself more and more from the nepionic conch, only a narrow fleshy band is left behind, a new narrow tube is secreted by the latter within this older endosiphocoleon, as we have shown above [*see* pl.7, fig.2 and text fig.8]. This is the *endosiphotube*. As we have indicated in text figure 13, no differentiation between these tubes has yet taken place near the apex. If we take the long slender nature of the apical conch in account, it appears quite probable that the two tubes

do not separate for some time and perhaps not till the neanic stage is reached.

The *neanic* stage is one of continuous growth. It begins with the filling of the nepionic bulb and the accomplishment of the withdrawal therefrom, and ends with the cessation of the formation of cameras and the secretion of the last and terminal endosiphosheath. Its substages are not clearly defined but since the differentiation of the endosiphocoleon and endosiphotube takes place in this stage, it is possible that one substage, perhaps the metaneanic, will be found to be marked by this differentiation. The advance of the endosiphocone with the attendant secretion of endosiphosheaths, forward growth of the endosiphocoleon and, lagging behind, of the inclosed endosiphotube, persisted during a great part of the individual lives of the species here under discussion, as is demonstrated by the considerable length of the conch through which these structures pass with but slight change. The adolescent stage and notably its last or its last two substages were hence remarkably long. The endosiphocoleon is decidedly the most striking endosiphonal structure of this stage.

When finally *maturity* was reached there were still available to the animal the living chamber, a very long portion of the wide and open siphuncle and the endosiphocone, which was closed by the last and final endosiphosheath. The latter and the last formed portion of the endosiphocoleon are characterized by specially thick walls, formed during ephebic age. Further growth took place only by a lengthening of the living chamber at its anterior margin.

Gerontic characters have not been observed.

The following tabulation may serve to bring out the differences of the three principal growth stages of this species in more concise form:

Growth stages of Cameroceras brainerdi Whitfield

STAGE	SUBSTAGES	CONDITION OF CONCH
Embryonic stage		Protoconch not retained
Nepionic or larval stage	Ananepionic Metanepionic Paranepionic	The conch is at first but an open unchambered, conchiolinous shell (ananepionic substage). With further growth a part of the space inclosed within the conch is set apart by septa as cameras, and thus the phragmocone or chambered portion of the conch becomes separated from the open cone (metanepionic substage). Then the nepionic bulb becomes filled by endosiphosheaths and intercalated organic carbonate of lime (paranepionic substage).
Neanic or adolescent stage	Ananeanic Metaneanic Paraneanic	Continued growth of the animal necessitates continuous formation of cameras and of endosiphosheaths and leads to a widening of the siphuncle and the separation of an endosiphotube and endosiphocoleon.
Ephebic or mature stage	Anephebic Metephebic Parephebic	The siphuncle is open, separated from the phragmocone by the ectosiphuncle (contiguous septal necks) in the anterior portion; by the ectosiphuncle and endosipholining in the posterior portion. The endosiphocone is bounded hy the final endosiphosheath. Further growth of the conch is only apparent along the apertural margin of the living chamber.

6 Relations of Proterocameroceras to Cameroceras, Vaginoceras and Nanno

A reference of our species to any of the genera of the Endoceratidae is beset with considerable difficulty. A short historic review of the varying generic references of the two most nearly related forms, Vaginoceras belemnitiforme and Nanno aulema, will demonstrate this. The first form with a free apical cone or nepionic bulb was described by Holm as Endoceras belemnitiforme [1887, p.5]. The author of the species named stated that it is unknown whether the

apical conch in the genus Endoceras agrees with the form described, but added that he was able to trace in several species of Endoceras the apical portion to a diameter of a few millimeters, and that in all of them it was simple and conical, and possessed septa and siphuncle like the remainder of the phragmocone.

In 1894 Clarke described a species with similar apical cone from the Trenton beds in Minnesota, making it the type of a new genus, N a n n o a u l e m a [1894, p.205]. In the Minnesota report [1897, p.770] this interesting form has been described very elaborately and it has been pointed out there that "the continuance of an aseptate condition for a considerable period in the early history of Nanno is itself indicative of an important difference from Endoceras (Cameroceras) and Piloceras, inasmuch as this determines it to have been a more elementary organism than either." Holm's species is here also referred to Nanno. It is evident that both observers saw in the free apical cone a differential feature of considerable importance.

On account of Holm's conservative reference of his species to Endoceras, the validity of the genus Nanno was questioned by several authors (Sardeson, Bather). Holm himself discussed the relations of the endosiphonal structures soon after [1895, p.616] and came to the conclusion that inasmuch as it is not yet established that the apexes of all species of Endoceras have not the same structure as that of E. b e l e m n i t i f o r m e, the only difference between Endoceras and Nanno consists in the unequal longitudinal and transverse dimensions of the siphonal apical cone: the siphuncle of Nanno attaining its greatest width within the apical cone, whence it decreases to the beginning of the cameration, while in the other Endoceratidae the siphonal apical cone began undoubtedly very small, and the siphuncle increased gradually within the chambered conch. For this reason he adopted the term Nanno for a subgeneric group of Endoceras and in the following year (1896) described two additional types of this subgenus, adding also another subgenus Suecoceras. He redefined the subgenus Nanno, seeing its principal diagnostic character in the inflated apical cone which corresponds in length to the combined length of at least three of the oldest cameras, and which thereafter contracts so rapidly that already within

the third camera the siphuncle attains its normal dimensions. This subgenus is made to include Nanno aulema, Nanno belemnitiforme and two new smaller forms. It is apparent that we would have to enlarge greatly the definition of this subgenus if we wished to commit our form, with its very long but slightly inflated apical cone, to it.

The question is, however, quite differently viewed by Hyatt. This foremost of the later authors on fossil cephalopods subjected the remarkable type from the Minnesota Trenton to an independent investigation and came to a different conception of the genus Nanno [1895, p.1]. It is evident from his discussion of the relations of Nanno to other genera, as also from his reference of Holm's species Endoceras (Nanno) belemnitiforme to Vaginoceras and his later definition of the genus in Zittel-Eastman's handbook [p.515], that he did not see in the large inflated apical cone more than a primitive character of the nepionic stage, which may be retained in various genera, but considered the restriction of the "endosiphuncle" (endosiphotube) to the apical end as well as the absolute contact of the shell and siphuncular wall on the ventral side, which leads to a bending of the sutures apically into a lobe passing around the siphuncle, as those characters of Nanno which are of generic importance and differential from the similar genus Narthecoceras. Thus defined, the genus Nanno becomes restricted to the single species Nanno aulema and this is to be regarded as a modified descendant of a genus which retains the endosiphotube throughout life. In regard to Cameroceras brainerdi we have shown that the endosiphotube passes not only through the apical cone but also through a large portion of the siphuncle of the shell to a point near the endosiphocone where it enters the endosiphocoleon. For this reason a reference to the restricted genus Nanno is impossible even if the siphuncle were in as close contact with the conch in our species as in Nanno aulema.

The septal necks or funnels of the Valcour form reach only from the septum of origination to the next apicad of this [*see* pl.1, fig.2], and the siphuncle is lined by an inner, thick, continuous layer (endosipholining). If we, hence, accept Hyatt's division of the forms originally comprised under Endoceras into the genera Vaginoceras, Cameroceras and Endoceras by the criterion of the relative

length of the funnels, and the presence or absence of the inner siphuncular lining, our form would have to be brought under Cameroceras. We would then be in the peculiar situation of having three groups of species belonging to three different genera which have in common large preseptal apical cones or nepionic bulbs, indicating long continuation of a very primitive condition in early youth of the forms. In at least two of these genera these primitive groups contrast with the larger number of the younger congeners, in which the siphuncle has been entirely inclosed into the phragmocone and the preseptal cone superseded.

While we do not intend to question Hyatt's view which clearly considers the genus Nanno with the scope and definition given to it by Clarke and Holm, as of polyphyletic origin, and therefore restricts it to Nanno aulema, we are also convinced that it would not serve the ends of a proper delimitation of closely related and equally advanced forms, if one would include in these three genera the forms which clearly represent an older phylogenetic stage than the genotypes. For this reason we propose to separate these phylonepionic forms characterized by preseptal cones from the later and typical phylephebic congeners and designate them as subgenera by the prefix "protero." We thus have a "Proterocameroceras" represented by Proterocameroceras brainerdi, which is a Cameroceras with a large preseptal cone or nepionic bulb; and a "Proterovaginoceras," which is a Vaginoceras with a like cone. To the latter would have to be referred Endoceras (Nanno) belemnitiforme Holm, while the position of E. (Nanno) fistula Holm and E. (Nanno) pygmaeus Holm is uncertain till their siphuncular structures have been studied. As the long, stafflike, cylindric conchs would indicate, they may belong to neither of the two genera mentioned and be rather genuine Nannos or come under Hyatt's genus Narthecoceras. In the latter case we might have a third genus with "protero" forms and later forms.

It is in line with the more primitive character of Proterocameroceras brainerdi that it occurs in the Beekmantown formation; while Cameroceras does not find its principal development till the Black river and Trenton stages.

The close similarity in the structure of the apical portion of the conchs of Proterovaginoceras belemnitiforme and Nanno aulema has been recognized by Clarke, Holm and Hyatt. We have found a like nepionic siphuncle in Proterocameroceras brainerdi. Proterovaginoceras belemnitiforme and Proterocameroceras brainerdi have further in common the strong development of the peculiar organ which we have termed the endosiphocoleon, leaving as structural differences only the different length of the septal necks or funnels and the presence of the endosipholining in the latter. The phylogenetic relationship or common origin of the Proterovaginoceras-Vaginoceras series, the Proterocameroceras-Cameroceras and the Nanno series is therefore not to be doubted. Of these again the Vaginoceras series has retained the most primitive characters, as is apparent by the longer septal necks. A Vaginoceras-like form is therefore with great probability to be considered as the common radicle of the entire group. This form, which in the appended diagram we have designated as "Protovaginoceras," would have to be looked for in stages still preceding the late Beekmantown.

Our view of the relation of the species of Vaginoceras, Cameroceras, Nanno and Piloceras[1] attained here is expressed in briefer form in the following table.

	VAGINOCERAS SERIES	CAMEROCERAS-ENDOCERAS SERIES	NANNO SERIES	PILOCERAS SERIES
Typical or mature development	Vaginoceras multitubulatum (Vaginoceras wahlenbergi) (Vaginoceras vaginatum) etc.	Cameroceras trentonense, Cameroceras proteiforme	? (Nanno) fistula ? (Nanno) pygmaea	Piloceras
Proteroforms	Proterovaginoceras belemnitiforme	Proterocameroceras brainerdi	Nanno aulema	(Proteropiloceras)
Protoform	Protovaginoceras			

[1] *See* chapter 8, p.329.

7 Similarity between the endosiphocoleon and the proostracum of belemnites

An inspection of the system of surface lines of the endosiphocoleon consisting of forward arching transverse ridges and longitudinal lines can not fail to suggest the proostracum of the belemnites; and a study of the relative position of the two organs and of the probable phylogenetic relations of the Belemnitidae with the Endoceratidae makes this comparison seem less farfetched or strained than would appear at first glance.

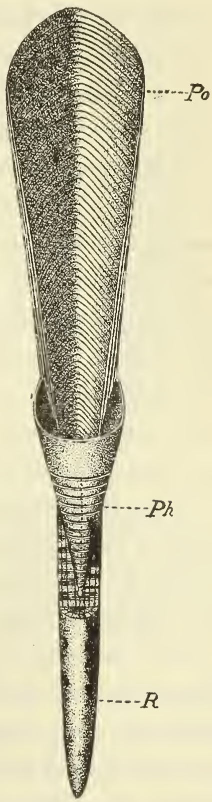

Fig. 20 Restoration of a Belemnite shell: *R*, rostrum; *Ph*, Phragmocone; *Po*, Proostracum. (Copy from Zittel)

The belemnite shell, when complete, consists, as is well known, of three parts [*see* text fig.20]. These are the rostrum, the phragmocone and the proostracum. Of these the rostrum or guard is a later acquisition which does not concern us here. The phragmocone is identical with the phragmocone of the early cephalopods which here however has become entirely inclosed within the mantle. From the dorsal side of the last large chamber of the phragmocone (the former living chamber of the conch) proceeds a broad, thin, somewhat arched blade, the proostracum, which consists of two stronger longitudinally striated lateral regions and a very thin intercalated dorsal blade. In the typical belemnites this organ has a size much surpassing that of the rostrum and phragmocone as in the restoration here copied; and in later forms both the latter organs become reduced,[1] while, on the other hand, if the Belemnitidae are traced backward in geologic history, the proostracum becomes smaller and more insignificant and the Triassic forms do not seem

[1]The homologies of the different parts of the cuttlebone or sepion of the Sepia with those of the belemnite shell are not yet clearly established as the differing views of Bather [1888, p.298] and Blake [1888, p.376] evince.

to have yet acquired it, while inversely the phragmocone, as in Atractites, was still so well developed that this genus was at first unhesitatingly referred to Orthoceras. Where the proöstracum is fully developed the animal has discarded the phragmocone entirely as living chamber, and inclosed this former exterior conch within the mantle whereby the rostrum and phragmocone find their position in the posterior end of the animal.

The endosiphocoleon, which externally resembles the proostracum, lies within the anterior part of the siphuncle. It is, as we have demonstrated, formed within the endosiphocone. As now the endosiphocone contained the posterior portion of the animal ("visceral cone" of Bather), and this was inclosed by the mantle, the endosiphocoleon forming at the posterior end of the visceral cone was undoubtedly produced by the mantle and since the surrounding endosiphosheath was left behind by the outer mantle, this more anterior endosiphocoleon is to be considered as secreted within a mantle flap or fold situated at the posterior end of the animal. Both the endosiphocoleon and proostracum are hence formed in identical places.

If we further take into account that while in our Proterocameroceras a large portion of the siphuncle served as chamber of habitation to the animal, and that in the Belemnitidae the animal had entirely withdrawn from the conch, the different position of the endosiphocoleon and of the proostracum relative to the phragmocone will be seen not to constitute a fundamental distinction. One might say that the animal in withdrawing first from the siphuncle and finally also from the living chamber pulled the endosiphocoleon after it till the latter came to lie in front of the old living chamber of the phragmocone.

It can not be held that the proostracum is a direct further development of the endosiphocoleon in view of the fact that the latter is only found in the early Endoceratidae and could have no place in the later orthoceracones with their shrunken siphuncles, while, on the other hand the proostracum does not appear till the phragmocone has been reduced to a rudiment in the Belemnitidae. But since the Belemnitidae, as Hyatt has claimed,

can be linked to paleozoic orthoceraconic cephalopods and the latter again quite probably took their origin from endoceratitic forms—by way of Baltoceras—and since therefore there is good reason to consider the Belemnitidae as descendants of the Endoceratidae, the similarity of the proostracum and endosiphocoleon is probably more than a mere analogy between unrelated forms due to formation by a like organ (mantle) in the like posterior position, but it partakes more of the nature of the recrudescence of an organ discarded before, when a new use had been found for it within the same race.

It does not matter that the endosiphocoleon is a flattened tube and the proostracum only a blade, as a flattened tube would be readily changed into a blade under the stress of a new adaptation.

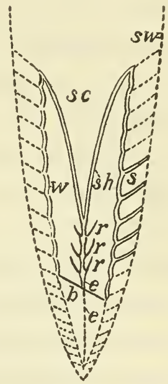

Fig. 21 Piloceras amplum Dawson. Longitudinal section; showing endosiphocone [*s c*], last endosiphosheath [*s h*]; endosiphotube [*e*] and remains of endosiphosheaths [*r*]. Dawson's original drawing. (Copy from Foord)

8 Endosiphuncular structure of Piloceras

We have already anticipated the results of our investigation of Piloceras in the synoptic table on page 326, in deriving Piloceras from a more primitive genus Proteropiloceras, that stands on the same plane of phylogenetic development as Proterocameroceras and Nanno. We have also recorded [p.301] that in Piloceras an endosiphoblade has been observed by Dawson, which indicates that the endosiphuncular structure may not only be homologous to that of Cameroceras by the possession and strong development of the endosiphosheaths, but also by the character of the endosiphuncular tubes.

While, however, in the few specimens of Piloceras in which the apical end has been actually observed, no nepionic bulb has been found, and the siphuncle has been seen to expand gradually and to be inclosed entirely within the phragmocone [*see* Foord], we have found that P. explanator Whitfield at least retains very distinct traces of the nepionic bulb or apical inflation [*see* pl. 13, fig.3]. This species points hence clearly

to the existence of types which held the same relation to the phylephebic species of Piloceras as does Proterocameroceras to Cameroceras; and which would be properly called "Proteropiloceras." If in P. explanator the cameras did not extend on one side to near or quite to the apex of this nepionic bulb, we would not hesitate to make this form the type of the proposed subgenus. It is evident that a process of acceleration in the phylogeny of this genus has led to a crowding back of the formation of septa, which originally was the cause of the contraction of the siphuncle, to the very apex of the nepionic bulb without, however, having yet been able to efface all vestiges of this former inflation of the conch. This also points clearly to the process by which the nepionic bulbs of Proterocameroceras and Proterovaginoceras have become reduced in Cameroceras and Vaginoceras, i. e. by a tachygenetic encroachment of the metanepionic growth stage on the aseptate ananepionic stage.

Besides the presence of the nepionic bulb, Piloceras exhibits also in its endosiphuncular structure characters which link it closer to the Protero-forms of the other associated series, than to Cameroceras.

The siphuncle is, like the conch, short, conical, with elliptic to oval section [*see* pl.10]; the endosiphocone is short and broad with elliptic upper section, rapidly shrinking to a flat blade at its narrower end [*see* pl.13, fig.1, 2]. Its cast shows peculiar flutings arranged in bundles and which, in one specimen, appear to consist of longitudinally arranged pits and strongly remind one of the similar depressed lines found on the outer conch. Since the latter are produced by muscular attachment of the animal within the living chamber, the presence of these scars on the wall of the endosiphocone seems to me a strong argument for the view that in this primitive form the visceral cone shared still to a great measure the functions of the living chamber. We have already seen that in Proterocameroceras brainerdi a large anterior portion of the siphuncle remained unobstructed by deposits and was evidently occupied by the animal during its lifetime. In Piloceras explanator this portion of the siphuncle was considerably wider

though not longer, for this reason probably amounting to as large a proportion of the animal as in Proterocameroceras.

Endosiphosheaths and endosiphofunicles. The endosiphosheaths were, corresponding to the heavy weight they had to support, rather stout membranes, reaching in some instances a thickness of 1mm. They are mostly well preserved, sometimes closely crowded and separated by intervals not wider than .5mm [*see* pl.12, fig.5]; but in at least one instance they were also separated by an open space of 5mm into which calcite crystals freely project. Their sections are not evenly curved ellipses, but partake more of the nature of polygonal surfaces or are even bounded by undulating lines. This is due to their being held in position by guy ropes or funicles, which we will designate here as "endosiphofunicles." These are of the same nature as the endosiphosheaths and appear in sections as dark gray to black pillars of organic carbonate of lime, often bounded by black lines. They originated from membranous funicles, in which organic carbonate of lime was deposited in similar manner as in the endosiphosheaths. The sections [pl.11, pl.13, fig.3] show them well developed. Several have been further enlarged to show their relation to the endosiphosheaths [*see* pl.12].

If it were not for the outward curvature or angulation of the endosiphosheaths [*see* pl.12, fig.1, 2] at the points of connection with the endosiphofunicles, and for the fact that the outer wall of the siphuncles passes over these funicles [*see* pl.12, fig.2; pl.13, fig.5], one might be inclined to consider them as worm tubes; specially where they appear in such great numbers as in plate 11, figure 2. But in this latter section it will be noticed that the greater number pass only from the outer wall of the siphuncle to the first endosiphosheath; while but a smaller number—among these the remarkable one in the upper right corner which bifurcates three times [*see* pl.12, fig.1]—reach the inner endosiphosheath or the endosiphocoleon.

In looking over the series of sections, beginning with figure 1 [pl.11] we will readily notice that the number of endosiphofunicles diminishes very rapidly with the shrinking of the endosiphosheaths

toward the apical end. This can be easily explained by the fact that the endosiphocone in its anterior part needed the most guy ropes on account of the greater weight of the visceral cone there. Therefore also the number of endosiphofunicles diminishes so greatly from the outer zone to the next, because the outer endosiphosheath inclosed a much larger section of the visceral cone at the plane of the section than the later inner endosiphosheath did at the same point.

In section I the endosiphofunicles of the outer whorl appear distinctly as fine tubes with thin conchiolinous walls, their lumen being filled by a milk-white calcite which strongly contrasts with the more limpid calcite crystals surrounding the tubes. Many of these tubes bifurcate near the ectosiphuncular wall, one several times. There is secured by this mechanical contrivance a larger base of fixation, which insures steadiness and freedom from vibrations for the visceral cone during the movements of the animal.

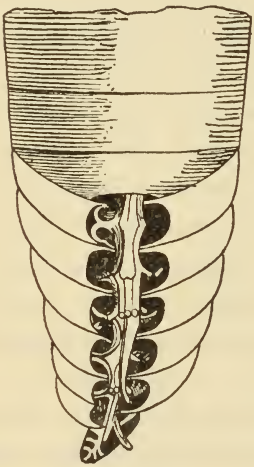

Fig. 22 Actinoceras abnorme Hall (sp.). Section showing the endosiphuncle and tubuli. (Copy from Zittel)

Whether the numerous endosiphofunicles were but a modification of the endosiphoblades which, as we have seen, hold the endosiphocoleon and endosiphosheaths in position in Proterocameroceras brainerdi and originated by a dissolution of these suspensory membranes in numerous strands, or are a new formation induced by the necessity of supporting the heavy visceral cone hanging free within the broad siphuncle, is a question which we can not con-

NOTE. We can not yet determine whether these endosiphofunicles are homologous to the remarkable verticils of sometimes branching tubuli which in some species of Actinoceras connect the endosiphuncle with the ectosiphuncle. Both undoubtedly are quite similar in appearance. The tubuli of Actinoceras [*see* e. g. Actinoceras abnorme Hall, N. Y. State Mus. 20th An. Rep't, pl. 18, fig. 10 (copied here after Zittel)] are by Foord described in Actinoceras bigsbyi [*see* 1888, p. 166] as penetrating the siphuncular wall, and it has been suggested by Owen [Pal. 1860, p.85] that they served for the passage of blood vessels to the living

clusively answer. But the fact that the endosiphocoleon is also here in the earliest successive sections of the siphuncle [*see* pl.11, fig.5, 6] supported either by continuous membranes proceeding from its corners or by longitudinal series of closely arranged endosiphofunicles would argue for a derivation of the endosiphofunicles from the endosiphoblades. That indeed in the apical portion of the siphuncle one of the two mentioned modes of suspension prevailed is to be inferred from the fact that in the above cited succeeding sections—and as well in the sections found on the other side of the cutting planes and separated from them by about 1mm—the dark lines which are the sections of the suspensories, retain the same position throughout.

The arrangement of the endosiphofunicles and endosiphoblades in the sections [pl.11] shows quite conclusively that the side of the siphuncle which is the upper in the drawings was also the upper side during the life of the animal. In the longitudinal section [pl.13, fig.3], which exhibits a series of endosiphofunicles the direction of the latter is of still further interest as giving a hint as to the direction in which the animal carried its conch. We notice that if we give the endosiphofunicles a perpendicular position, such as they should have according to their function as suspensories the conch assumes a direction which is obliquely ascending under a small angle. This stands in full accord with what we know thus far as to the dorsal and ventral sides of the animal; the siphuncle being in contact with the ventral wall of the conch, while the chambers form on the upper (dorsal) and lateral sides.[1] The fact brought out by the outline of a large specimen given by Whitfield that the ventral side is nearly straight,

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membrane of the septal chambers; while Hyatt [1883, p.272] believes with Barrande that they did not penetrate the true external wall of the siphuncle. If Barrande and Hyatt are right in this contention and Hyatt also in his view that the "rosettes" or endosiphuncular deposits of Actinoceras are strictly homologous to the endosiphosheaths of Endoceras and Piloceras [1883, p.27] the endosiphofunicles of Piloceras explanator may indeed be homologous to the "tubuli," and their function identical, viz, that of suspensories for the siphon, whose outer membranes have become calcified.

[1]In the section the chambers of course appear only on the upper (dorsal) side.

while the dorsal one is very convex, or in other words, that the ventral side appears as a base, all growth taking place in dorsal direction, tends also to support the view that the conch was carried slightly oblique and at rest placed in a horizontal position.

Fig. 23 Diagram of original cephalopod. (Copy from Lancaster)

It is interesting to note in this connection the views held by prominent zoologists as to the polarity of the Cephalopoda. Huxley, Lancaster and Lang give the original cephalopod the position shown in the diagrammatic figure reproduced here from Lancaster, while Verrill holds that the antero-posterior axis of the cephalopod is shown by forms as Loligo at rest [*see* fig.24]. It seems that the structure of Piloceras explanator, which both in organization and the time of its appearance is to be considered as a primitive form, could be easily reconciled with this latter view, if we assume that it was a sluggish creeping form which would rest its shell on the flat ventral side, but lift it up slightly while moving.

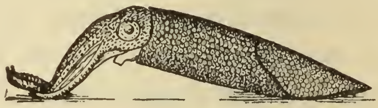

Fig. 24 Loligo at rest. (Copy from Verrill)

Endosiphocoleon. It remains to us to trace the development of the endosiphocoleon of the siphuncle of Piloceras explanator, which can be best done by reference to the series of sections 1–7 on plate 11.

We have already stated that the endosiphocone becomes flatter as it approaches its posterior end till at its termination it is five or more times as broad as high [*see* pl.13, fig.2]. From this end proceeds the endosiphocoleon, a flat sheathlike canal, which is nearly as wide as the innermost endosiphosheath; in section 1 by a secondary fracture apparently still wider. The longitudinal section [pl.13, fig.3] shows this endosiphocoleon in a young specimen, cut through its shorter axis. It demonstrates that the endosiphocoleon possesses a thin conchiolinous wall which extends through the last endosiphosheath into the cavity of the endosiphocone; and hence was here not formed as a continuation of the external conchiolinous layer of the endosiphosheath, but within the apical end

of the endosiphocone. It is hence identical in origin with the endosiphocoleon of Proterocameroceras brainerdi.

From its lateral ends proceed the endosiphofunicles described above, apparently mostly in longitudinal series. Corresponding to the vertical contraction of the siphuncle the section of the endosiphuncular canal is broader than high and its lateral ends coalesce into a conchiolinous blade. As the central portion retains its full lumen, the section becomes in this specimen at first very broadly triangular [fig.4] and finally (through fig.5, 6) a low triangle. The apical termination of this endosiphuncular canal is not shown in the specimen here sectioned because the ventral portion of the siphuncle has been worn away. There is, however, not more than 11mm wanting of the total length of the siphuncle, and it is therefore evident that no endosiphotube with distinctly circular conchiolinous wall passes, as in Proterocameroceras brainerdi, through a large apical portion of the siphuncle. The coloring of the calcite within section 4 suggests perhaps [*see* enl. pl.12, fig.3] that also here only a lumen with circular section may have remained open within the endosiphocoleon, but the next section (5) fails entirely to show any inclosed tube.

We have hence no evidence of the formation of an endosiphotube in Piloceras explanator, but do not doubt that where the siphuncle becomes longer and more tubular instead of remaining short and broad as in this species, an endosiphotube may be formed, as indeed it has been found in other species of Piloceras.

The wings of the endosiphocoleon in Proterocameroceras brainerdi, which originate from a deposit of conchiolinous matter on the outside of the endosiphosheath and which there form such a striking feature, have been observed in but one instance, where the apical portion of the siphuncle is extremely broad and flat and the lateral margins of the endosiphosheath form hence acute angles. They seem for this reason to have been strengthened by conchiolinous deposits.

Among the eight species of Piloceras which have thus far been described, one, P. newton-winchelli Clarke [1897, p.767],

from the Shakopee formation in Minnesota is of special interest in relation to the genetic history of this genus and in our opinion stands at the opposite end of the series from P. explanator. While in the latter the ectosiphonal wall distinctly consists of the coalesced reflexed margins of the septa (septal necks), Clarke's careful description and figures [*see* fig.25] demonstrate that in P. newton-winchelli the funnels or septal necks are only very short and the siphuncular wall is distinctly formed by a secondary formation, "the annuli".[1] If we adopt Hyatt's fundamental division of the Nautiloidea, we find the genus Piloceras brought under the Holochoanites which are characterized by the extension of the funnels from one septum to the next preceding or beyond. Piloceras newton-winchelli is hence not a member of the genus Piloceras as defined by Hyatt, indeed it has the ectosiphuncular structure of another suborder, the Orthochoanites; or has advanced in the character of its ectosiphuncle from the Cameroceras stage found in the other Piloceras forms, to the later Orthoceras stage. The relation of this form to the typical Piloceras appears to us identical with that of Endoceras burchardii Dewitz to the true Endoceras, the latter being a species which, while retaining the habit of an Endoceras has, as Holm has shown [1897, p.171] the ectosiphuncular structure of an Orthoceras. Holm proposed the genus Baltoceras for this form, a genus which is considered by Hyatt as the first and most primitive of the genera of Orthoceratidae.

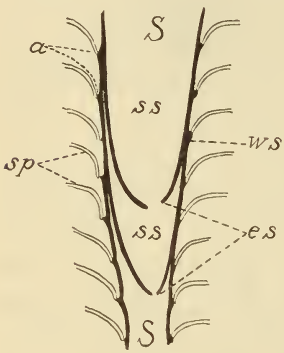

Fig. 25 Clarkoceras newton-winchelli Clarke (sp.). Enlargement of portion of section to show the siphuncle [*S*]; endosiphosheaths [*ss*]; ectosiphuncle [*ws*]; endosiphotube [*es*]; septa [*sp*] and annuli [*a*]. (Copy from Clarke)

[1] It is doubtful whether these annuli or siphuncular segments of the Orthochoanites form a homologue to the continuous "endosipholining" of Cameroceras, as it would appear at first glance. The endosipholining is considered by Hyatt as composed of the upper unresorbed ends of the endosiphosheaths, while the siphuncular segments find their fullest development where, on account of the reduction of the siphuncle, no more endosiphosheaths are formed. Nor is any genetic connection between the segments and the endosiphosheaths apparent in text figure 25.

On the same principle P. newton-winchelli should be removed from the holochoanitic Piloceratidae and brought under the Orthochoanites, where, as far as I am aware, it constitutes a new genus (Clarkoceras).

A further character quite significant of the advance of Clarkoceras newton-winchelli beyond the typical Piloceras stage is to be seen in the reduction of the endosiphosheaths of which only two were observed in a specimen of which only a small apical portion is missing [*see* fig.26]. These leave large endosiphuncular chambers between them which are not filled by depositions of lime carbonate, as the much smaller chambers in the species of Piloceras are. The endosiphotube is only indicated by the perforation of these endosiphosheaths and has lost its own wall. The entire endosiphuncular structure is distinctly in a process of dissolution, resulting from the reduction of the size of the siphuncle in consequence of the more complete withdrawal of the visceral cone. In Baltoceras the process of dissolution has gone already a step farther and all traces of endosiphosheaths have been lost notwithstanding the still considerable width of the siphuncle.

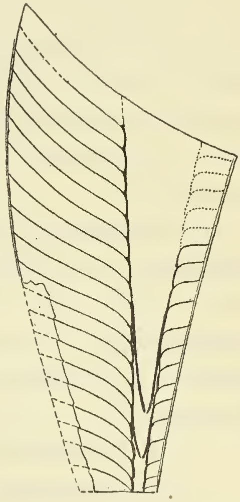

Fig. 26 Clarkoceras newton-winchelli Clarke (sp.). Median vertical section of a specimen. x1.5. (Copy from Clarke)

Summary

1 The conch of Cameroceras brainerdi from the Upper Beekmantown formation begins with a long slender preseptal cone or nepionic bulb, which terminates anteriorly with a slight constriction where septation sets in.

2 The nepionic bulb and the middle (neanic) portion of the siphuncle are filled by endosiphosheaths, while the anterior (ephebic) portion is empty.

3 The empty anterior portion is closed in apicad direction by the final endosiphosheath, which incloses the endosiphocone

(visceral cone). From this last formed endosiphocone a broad, flattened tube with conchiolinous walls extends backward, for which the term "endosiphocoleon" is here proposed. This forms within the endosiphocone preparatory to a further withdrawal of the animal and the formation of a new endosiphosheath. In apicad direction it changes into a blade, consisting of two lamellae, disappearing gradually by being altered into organic calcium carbonate and becoming confluent with the calcium carbonate filling of the siphuncle. The endosiphocoleon grew hence at its anterior end and was absorbed at its posterior end or vanished there by secondary alteration into lime carbonate.

4 In the same measure as the endosiphocoleon disappears, a capillary conchiolinous tube, the endosiphotube, becomes prominent. This forms within the endosiphocoleon by the posterior contraction of the siphon. It extends to the apical end of the nepionic bulb, where it empties (into the protoconch which is not preserved).

5 The endosiphocoleon is flanked on both sides by conchiolinous wings, having a crescentic section. These form on the outside of the angles of the flattening endosiphosheaths and are hence separated from the endosiphocoleon by the organic lime carbonate composing the endosiphosheaths.

6 The posterior portion of the empty, ephebic siphuncle is lined by the endosipholining, the anterior portion only by the septal necks or funnels.

7 The endosiphocone, endosiphocoleon and endosiphotube are held in position by (mostly three) radiating suspensory membranes (endosiphoblades), which affix the endosiphosheath etc. to the preceding endosiphosheath and the ectosiphuncle.

8 The presence of a preseptal cone or nepionic bulb in an early, otherwise typical, Cameroceras (C. brainerdi),—while in the later species of Cameroceras the nepionic bulb has disappeared—, as well as in a typical Vaginoceras (V. belemnitiforme), in Nanno aulema and in a Piloceras (P. explanator), demonstrates that these genera have passed through the same early

stage of development with a prominent nepionic bulb, which fact is of sufficient phylogenetic importance to require recognition by assigning these forms to subgenera (Proterocameroceras, Proterovaginoceras and possibly Proteropiloceras) of their respective genera.

9 The endosiphocoleon is revived in the proostracum of the belemnites, the probable Mesozoic descendants of the Paleozoic holochoanitic and orthochoanitic orthoceraconic cephalopods.

10 In Piloceras explanator Whitfield the nepionic bulb is still recognizable by an inflation of the apical portion of the siphuncle, which by tachygenesis has become inclosed in the phragmocone.

11 The endosiphocoleon extends without becoming absorbed to or nearly to the apical end. This results from the wide short form of the siphuncle.

12 The endosiphosheaths and endosiphocoleon are held in position by numerous suspensory funicles (endosiphofunicles). These proceed from angulations of the endosiphosheaths and frequently divide in outward direction.

13 The arrangement of the endosiphofunicles on the side opposite the flat side of the conch, where siphuncle and conch are in contact, indicates that this latter side may have been the ventral one and that the conch was carried in a subhorizontal, slightly ascending direction.

14 Piloceras newton-winchelli Clarke is by the structure of its ectosiphuncle not a holochoanitic form as the other congeners, but an orthochoanitic form and represents a genus (Clarkoceras) which holds the same relation to Piloceras as Baltoceras to Endoceras.

References

1867 **Barrande, J.** Système Silurien de la Bohême, v.2. Cephalopodes (1867-77), t.430, f.5, 8-11 ; t.471, f.8-10.

1879 **Dewitz, H:** Beiträge zur Kenntniss der in den ostpreussischen Silurgeschieben vorkommenden Cephalopoden. Schriften der physik.-oekon. Gesellsch. in Königsberg. Bd 20.

1880 ——— Ueber einige ostpreussische Silur-cephalopoden. Zeitschr. d. deutsch. geol. Gesellsch. 32:371-93, Tafel XVI-XVIII.

1881 **Schröder, H.** Beiträge zur Kenntniss der in ost- und west-preussischen Diluvial-Geschieben gefundenen Silur-Cephalopoden. Schriften der phys.-oekon. Gesellsch. in Königsberg. 1881. Bd 22.

1881 **Whitfield, R. P.** Observations on the Purpose of the Embryonic Sheaths of Endoceras and their Bearing on the Origin of the Siphon in the Orthocerata. Am. Mus. Nat. Hist. Bul. v.1, no.1, p.20.

1883 **Dawson, J. W.** Palaeontological Notes I. A New Species of Piloceras. Can. Nat. n. s. 10:1-4.

1884 **Hyatt, Alpheus.** Genera of Fossil Cephalopods. Bost. Soc. Nat. Hist. Proc. 22:253-338.

1886 **Whitfield, R. P.** Notice of Geological Investigations along the Eastern Shore of Lake Champlain, Conducted by Prof. H. M. Seeley and Pres. Ezra Brainerd, of Middlebury College, with Descriptions of the New Fossils Discovered. Am. Mus. Nat. Hist. Bul. v.1, no.8.

1887 **Holm, G.** Ueber die innere Organization einiger silurischen Cephalopoden. Pal. Abhandl. von Dames & Kayser. 3:11-27.

1888 **Foord, A. H.** Catalogue of the Fossil Cephalopoda in the British Museum. pt1.

1888 **Blake, J. F.** Remarks on Shell-growth in Cephalopoda. Ann. & Mag. Nat. Hist. ser.6. 1:376.

1893 **Hyatt, A.** Phylogeny of an Acquired Characteristic. Am. Phil. Soc. Proc. 32:349.

1894 **Clarke, J. M.** Nanno, a New Cephalopodan Type. Am. Geol. 14:205.

1894 **Bather, F. A.** Cephalopod Beginnings. Nat. Sci. 5:422-36. (See his references)

1894 **Sardeson, F. W.** Note on Nanno. Am. Geol. 14:402.

1895 **Holm, G.** Om de endosifonala bildningarna hos familjen Endoceratidae. Geol. För. Förh. i Stockholm. 17:601.

1895 **Hyatt, A.** Remarks on the Genus Nanno. Am. Geol. 16:1.

1896 **Holm, G.** Om apicaländan hos Endoceras. Geol. För. Förh. i Stockholm. 18:394. *Also* G. F. F. 1897. 19:175.

1896 **Verrill, A. E.** The Opisthoteuthidae. A Remarkable New Family of Deep Sea Cephalopoda, with Remarks on Some Points of Molluscan Morphology. Am. Jour. Sci. ser.4. 2:74-80.

1897 **Clarke, J. M.** Lower Silurian Cephalopoda of Minnesota. Geol. Minn. v.3, pt2, p.760.

1897 **Holm, G.** Om ektosifo hos Endoceras Burchardii Dew. Geol. För. Förh. i Stockholm. 19:171-74.

1900 **Hyatt, A.** Cephalopoda; in Textbook of Palaeontology by Zittel, tr. by Ch. R. Eastman. 1:502.

NOTES ON THE SILURIC OR ONTARIC SECTION OF EASTERN NEW YORK

BY C. A. HARTNAGEL

The Ontaric section of central and western New York, as developed west of the Helderberg is subdivided into 10 divisions,[1] and it is from this section of the State that all but one of the locality names applied to these divisions are derived. Each of these divisions is more or less distinctly characterized by differential lithologic features and all are fossiliferous.[2]

On the east side of the Helderberg and including the section extending from Ulster county southwest to New Jersey, the Ontaric lacks several members of the group, while the fossils found are of an age not earlier than late Salina, the lower members of the Ontaric where present being entirely without fossils. The fact that the Manlius and Rondout formations alone of the entire Siluric series have stratigraphic continuity across the Helderberg, has left the outcrops of the Siluric rocks in New York divided into two nearly distinct geographic areas.[3]

While the main purpose of this paper is to bring out the relations of the Cobleskill formation as developed in eastern and southern New York, it will also attempt to show certain relations of the lower members of the Ontaric formation in so far as they have come under the observation of the writer. The lower members of the Ontaric section in this portion of the State are entirely unfossiliferous and confusing in their lithologic features, and it will still require considerable study to accurately locate their correct position in the geologic series. This condition is brought about by the discovery that the Cobleskill horizon is above the Salina deposits, a fact which suggests that the Shawangunk grit and red shales above it may possibly represent a later age than that to which they have been usually referred.

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[1] Clarke. N. Y. S. Mus. Handbook 19, July 1903. Table 1, p. 9.

[2] While the Salina beds are sometimes regarded as being nonfossiliferous, it will be observed that the Salina as now defined includes at its base the Pittsford shale and at its top the Bertie waterlime. Both of these formations are characterized by an Eurypterus fauna.

[3] A third area is developed in Rensselaer county. The Ontaric is here represented by a single member known as the Rensselaer grit. This is generally considered the equivalent of the Oneida or of the Shawangunk grit.

Shawangunk grit and conglomerate

The lowest member of the Ontaric section in eastern New York is the Shawangunk grit. This designation was first applied to the formation by Mather,[1] the term being derived from the mountain area of that name, which extends from near High Falls in Ulster county southwest through Orange county and beyond the limits of the State. The Shawangunk grit, wherever the contact has been observed, is seen to rest unconformably on the Lower Siluric shales. The Shawangunk grit is generally correlated with the Oneida conglomerate, the latter term often being applied to it. Of these two formations the Shawangunk grit has the greater development, the thickness varying from less than 50 feet in parts of Ulster county and gradually increasing in thickness to more than 200 feet within a few miles. The Oneida conglomerate in its type section has a thickness of from 15 to 20 feet and in its western extension it gradually grades into a sandstone known as the Oswego sandstone, which in Oswego county has a thickness of more than 100 feet. Both the Oneida conglomerate and the Oswego sandstone are transitional into the Medina sandstone above.

It will thus appear that while we may consider the Medina as directly following and transitional from the Oneida in central New York, the sequence of events following the deposition of the Shawangunk grit in eastern New York has never been satisfactorily established. While for many years the red shales lying above the Shawangunk grit in Ulster county and further south have been generally correlated with the Medina of central New York, no proof has ever been set forth to establish their identity with any degree of certainty. Mather[2] in the final report of the first district, the western limit of which was as far west as Herkimer county, did not definitely correlate these red shales, though he was inclined to refer them to the Medina. He says, "The observations made do not render it certain whether these red rocks are equivalent to the Onondaga salt group or the Medina

[1] Geol. N. Y. 1st Dist. 1843. p. 355.
[2] Geol. N. Y. 1st Dist. 1843. p. 355, 363.

sandstone; but it is thought probable, from some of the mineral characters, no fossils having been seen, that they belonged to the epoch of the Medina sandstone, and that the subjacent Shawangunk grit is equivalent to the gray sandstone (=Oswego) instead of the Oneida conglomerate."

While it is known that Mather[1] recognized and designated a formation in eastern New York as "coralline limestone" which recently has been shown to be identical with the Cobleskill limestone, it is evident from the above citations that Mather could not have regarded it as of Niagaran age, or he would not even have suggested the possibility of the underlying red shales being of Salina age. For many years following the publication of Mather's report the section under consideration was not much studied. The discovery, however, by Dr Barrett, of Cobleskill fossils near Port Jervis in strata which lie above the red shales, and the studies of Lindslay of the same formation at Rondout, left little doubt as to the continuity of these rock masses in the intervening section, and since the Cobleskill at that time was correlated with and generally accepted as the equivalent of the Niagaran formation as developed in western New York, it served for the time being as apparently conclusive evidence that the underlying shales could scarcely be correlated other than with the Clinton and the Medina, or at least it was not thought they could possibly represent the Salina. As we now know that the Cobleskill limestone is of an age later than the Salina, the age of the red shales together with the so called Clinton quartzite lying above the Shawangunk grit again comes into question, since both the Salina and the Medina are below the Cobleskill. As no fossils have been found in the red shales, a feature which contrasts them with the Medina of central New York, it is evident that in any attempt to correlate these red shales, evidence must be had from other sources.

It was early shown by Vanuxem[2] and Hall[3] that in central New York the passage from the Oneida to the Medina was a

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[1] Geol. N. Y. 1st Dist. 1843. p. 331.

[2] Geol. N. Y. 3d Dist. 1842. p. 71.

[3] Pal. N. Y. 1852. 2:15, 16.

gradual one, the conglomerate or the sandstone (Oswego) being transitional into the Medina. The lower portion of the Medina throughout the central portion of the State contains pebbles abundantly and is also characterized by an oblique laminated structure which is well shown in the exposures of the Medina in Herkimer county. On the other hand the base of the red shales (=High Falls shales) above the Shawangunk grit in Ulster county and farther southwestward do not possess the transitional features ascribed to the Medina of central New York. In the eastern section these shales are entirely devoid of pebbles, generally of a bright red color and uniform in character, specially near their base. On exposure to the atmosphere they break into small angular fragments which are easily washed away leaving the sloping surface of the conglomerate beneath clean and white. In small protected areas on the western face of Shawangunk mountain, where the agencies of weathering and erosion have been less severe and the shale, perhaps, of a firmer texture, a number of isolated patches of these red shales occur. They are, however, easily removed and the underlying conglomerate brought to view. On the farm of Patrick Winn at High Falls the contact of these red shales with the conglomerate is favorably shown. At this place the shales formerly were quarried and used for making paint. They here retain their characteristic features down to the conglomerate. It is evident then that there is a very marked change in the character of the sedimentation following the conglomerate, suggestive of a hiatus at this point. Nowhere in central New York has the base of the Medina the features presented by the red shales of this section. In lithologic features they are more like the Vernon red shales of the Salina than any bed of the Medina, though in the upper portion of the Medina there are beds of red shales of a somewhat similar character but more arenaceous. Such beds can be favorably examined at Lewiston on the Niagara river.

A study of the overlaps on the west side of the Helderberg shows that the Salina shales extend farther east than does the Medina, and since the period was one of increasing submergence,

it is but natural that we should expect to find in eastern New York manifestations of Salina time rather than the Medina and the Clinton. The so called Clinton quartzites (=Binnewater quartzites) lying above the red shales were so designated because they are in some respects similar to the Clinton formation of western New York, and probably also because of their similarity to the green shales with iron pyrites lying beneath the Cobleskill in Schoharie county which were formerly also correlated with the Clinton. In this connection it is interesting to note that the view as given above was held by Mather.[1]

With this correlation in view, it follows that, if the quartzite with the iron pyrites in eastern New York is the equivalent of the green shales of the Schoharie section then the quartzite of eastern New York is Salina and not Clinton, since it is known that the green shales of Schoharie county are of an age not earlier than late Salina. South from High Falls the quartzite below the Wilbur limestone becomes more calcareous and of a shaly nature. At Accord, a few miles south from High Falls, the shales are seen in the cut on the Ontario & Western Railroad. At this place the beds are light colored, soft, argillaceous shales with considerable mineral matter. They are exposed for a thickness of 18 feet. Southwest from this point there are no favorable exposures for the examination of these shales in New York.

If we regard the red shales above the Shawangunk grit and conglomerate as Salina in age, it is quite probable that the Shawangunk in this portion of the State is much later than has been generally supposed. Recent studies indicate that the Shawangunk represents the invading basal member of the Salina series.

Poxino Island shale

This is the term applied to irregular bedded, buff colored, calcareous beds which are exposed just across the New York State line in the Nearpass section in New Jersey and farther south. At the Nearpass section they are but obscurely shown for a thickness of 1 foot, and they here form the lowest member

[1] Geol. N. Y. 1st Dist. 1843. p. 353, 354.

that can be observed in the Nearpass section. These shales have not been identified with certainty in New York State. Near Cuddebackville a few miles north from Port Jervis, somewhat similar shales, but containing iron pyrites, have been observed. They hold a position below the Decker Ferry formation, but the contact with the Decker Ferry could not be observed. The shales below the Decker Ferry as recognized at Accord have a somewhat similar appearance to the Poxino Island shale. In this section the Bossardville limestone which lies between the Poxino Island shale and the Decker Ferry formation could not be observed. It is probable, however, that the Bossardville limestone has failed by thinning out before this section is reached. The age of the Poxino Island shales has as yet not been definitely established, but they probably belong to the Salina.

Bossardville limestone

No outcrop of this formation has been recognized in New York State, though it probably extends from New Jersey into Ulster county. At the Nearpass section, 3 miles south of Port Jervis, its entire thickness is shown to be slightly more than 12 feet. It directly overlies the Poxino Island shale and in lithologic features it much resembles some thin banded layers of the Manlius limestone. This is the lowest member of the Ontaric formation in this section that is fossiliferous, but even this is only sparingly so. Leperditia altoides Weller is found quite abundantly in several of the thin layers in the upper 2 feet of the limestone. Besides the Leperditia a single individual of the genus Oncoceras was found. This species is in some respects similar to O. ovoides Hall, but is smaller and probably a distinct species. The Bossardville limestone is regarded by the writer as a late representative of Salina time.

Decker Ferry formation

The term Decker Ferry formation as recently applied by Weller in the New Jersey section includes all the strata between the Bossardville limestone and the Rondout waterlime. The upper 6 feet of the formation as described by Weller may, how-

ever, be definitely correlated with the Cobleskill limestone, as typically developed in Schoharie county. The lower part of the formation is the equivalent of what has been termed Salina waterlime and Wilbur limestone in a previous report.[1]

FOSSILIFEROUS SECTIONS

The following fossiliferous sections extending from the well known locality of the Decker Ferry formation, as exposed 3 miles south of Port Jervis, and extending northeastward into Ulster county will serve to show the stratigraphic relations of the fossiliferous beds up to the Coeymans limestone.

Nearpass section 3 miles south from Port Jervis N. Y.

1 **Poxino Island shale.** In an excavation a little distance above the base of the cliff there is an exposure of a bed of buff shale 1 foot in thickness. This exposure is being rapidly covered by talus. No fossils.

2 **Bossardville limestone.** Thin banded limestone of alternate light and dark colored laminae. On account of the shaly nature of the rock, the entire thickness of slightly more than 12 feet can be readily examined; L e p e r d i t i a a l t o i d e s Weller found abundantly in layers near top; O n c o c e r a s cf. o v o i d e s Hall the only other fossil observed.

3 **Decker Ferry.** The lower 24 feet of this formation consists of several layers of hard crystalline limestone with some shaly beds. This portion of the section is highly fossiliferous and from the specially characteristic fossil C h o n e t e s j e r s e y e n s i s Weller, it has been designated the Chonetes jerseyensis zone. Though found in the other zones of the Decker Ferry formation and rarely in the Cobleskill limestone of Schoharie county, A t r y p a r e t i c u l a r i s Linn. is very abundant in the lower portion of the Decker Ferry, and farther north in Ulster county it is so plentiful as to make a distinct band in the Wilbur limestone.

4 **Decker Ferry.** Red crystalline limestone 2 feet. This layer is characterized by the species described by Weller as P t i l o-

[1] N. Y. State Paleontol. An. Rep't 1903, p. 1142.

dictya frondosa and is designated as the Ptilodictya frondosa zone. This limestone by reason of its distinctive lithologic and faunal features can not be confused with any other bed. No outcrop of this rock has been observed in New York.

5 **Decker Ferry.** The 15 feet of limestones and shales lying above the red crystalline limestone have no characteristic fossil to mark it as a distinct zone. Rhynchonella? lamellata occurs abundantly, but this fossil has a considerable vertical range and in some sections extends up into the Rondout. This zone may be regarded as transitional into the Cobleskill limestone. Its stratigraphic position is that of the lower cement bed of the Rondout section, but in the Nearpass section there are no cement beds.

6 **Cobleskill formation.** Six feet of limestone characterized by an abundance of corals, such as Prismatophyllum inequalis Hall, Halysites catenulatus Linné. This zone by reason of similarity in lithologic features and fossil contents may be definitely correlated with the Cobleskill limestone of Schoharie county where it is typically developed, with a thickness of 6 feet.

7 **Cobleskill formation?** Above the 6 feet of limestone designated the Cobleskill there are 4 feet of limestone in thin beds separated by shaly layers. Though containing Cobleskill fossils, the abundance of ostracodes present indicates a change in the nature of sedimentation, due perhaps to the introduction of brackish water conditions which lasted throughout Rondout time.

8 **Rondout formation.** Above the Cobleskill limestone in the Nearpass quarry section there are 39 feet of shales and limestones. In general lithologic features this formation resembles the Rondout as developed in New York State, but the cement bed so characteristic at the base of the formation farther north is absent here. With the exception of several species of Leperditia, fossils are extremely rare. Future studies may show that the 4 feet of limestones and shales at the base of this formation and which have been provisionally included with the Cobleskill belong to the Rondout.

9 **Manlius limestone.** This formation which is nearly 35 feet thick carries a typical Manlius limestone fauna. The fossils in some cases are not well preserved. This is specially true of Tentaculites gyracanthus Eaton, of which well preserved specimens are rare. From the Nearpass section, however, on the reverse side of a thin slab collected for specimens of Megambonia aviculoidea Hall, there was found Tentaculites gyracanthus equally as abundant as in the sections farther north in New York State. They are however in a very poor state of preservation and may readily be passed unnoticed.

ORANGE COUNTY SECTIONS

In the section a short distance southeast of Port Jervis at Carpenters Point neither the Cobleskill nor the Decker Ferry formations can be observed, though several members of the Helderbergian are shown at this locality. About 2 miles farther north from Carpenters Point the Erie Railroad crosses these formations but they are all too deeply covered to show any outcrops.

The best place in Orange county for the examination of the Cobleskill and Decker Ferry formations is in the valley of the Neversink about 8 miles north of Port Jervis and 1 mile east of Cuddebackville. Here there are a number of parallel ridges which include not only the Cobleskill and Decker Ferry formations, but the Rondout and Manlius together with the Helderbergian members of the Devonic.

About 1 mile southeast from Cuddebackville there is an old quarry with a limekiln near by. The beds here are nearly vertical, and just to the east of the quarry the Cobleskill together with the upper part of the Decker Ferry formation is shown. The rock is here much sheared and is traversed by mineral veins. This outcrop of the Cobleskill and others in the vicinity of the same horizon are noted by Ries[1] and are included by him with the Tentaculite (Manlius) limestone. The lower part of this outcrop is not favorable for collecting but in the upper part

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[1] N. Y. State Geol. 15th An. Rep't. 1898. p. 430, 433.

of the Cobleskill limestone close to the face of the quarry the following species were obtained.

1 Prismalophyllum inequalis *Hall*
2 Cyathophyllum *cf.* hydraulicum *Simpson*
3 Favosites helderbergiae *var.* praecedens *Schuchert*
4 Atrypa reticularis *Linné*
5 Camarotoechia litchfieldensis *Schuchert*
6 Leptaena rhomboidalis *Wilck.*
7 Orthothetes interstriatus *Hall*
8 Rhynchonella ? lamellata *Hall*
9 Stropheodonta bipartita *Hall*
10 Whitfieldella nucleolata *Hall*
11 Pleurotomaria ? *cf.* subdepressa *Hall*
12 Calymmene *cf.* pachydermatus *Barrett*
13 Dalmanites *sp.*
14 Leperditia *cf.* jonesi *Hall*

At this locality specimens of Leptaena rhomboidalis are plentiful and unusually well preserved. At the top of the Cobleskill in the portion that is transitional into the Rondout there are found thin bands of limestones separated by shaly partings. The shaly layers weather to a drab color and are easily removed from the face of the quarry. These thin layers contain quite abundantly Orthothetes interstriatus Hall and Leperditia scalaris Jones. The limestone bands are crowded with Whitfieldella sulcata Van. and Spirifer vanuxemi Hall. Orthothetes interstriatus Hall and Leperditia scalaris Jones are also found in the limestone bands. In the Nearpass section south of Port Jervis at the top of the Cobleskill there are found similar limestone bands characterized by many Beyrichias of which there are several species. In the latter section in these limestone bands brachiopods are also found, but Leperditia has as yet not been observed.

Northeast from this outcrop the Cobleskill and Decker Ferry formations are obscured for about a mile, but the Decker Ferry formation is again seen on the farm of Mr Cuddeback just in rear of the house. The Rondout is shown a little higher up on the ledge and the Manlius and Coeymans limestones a short distance farther to the west. A short distance to the west of the house of Mr Case and north of the outcrop back of Mr Cudde-

back's house the upper part of the Decker Ferry formation is shown and the following species were obtained.

1 Favosites *sp.*
2 Atrypa reticularis *Linné*
3 Camarotoechia litchfieldensis *Schuchert*
4 Chonetes jerseyensis *Weller*
5 Leptaena rhomboidalis *Wilck.*
6 Rhynchonella ? lamellata *Hall*
7 Spirifer *sp.*
8 Stropheodonta bipartita *Hall*
9 Pterinea *cf.* emacerata *Con.*
10 Dalmanites *sp.*
11 Proetus pachydermatus *Barrett*
12 Beyrichia *sp.*

The Cobleskill limestone is obscurely exposed in the field beyond, where also were found the thin limestone bands crowded with Whitfieldella sulcata Van. and Spirifer vanuxemi Hall, and which mark the upper limit of the Cobleskill.

Passing from this station northeastward into Sullivan county no outcrops of the Cobleskill have been observed. Throughout Sullivan county there is but little opportunity for the examination of the Siluric and Helderbergian rocks. The cliffs so prominent north from Port Jervis between the Neversink river and Shawangunk mountain become low in Sullivan county and almost entirely disappear. Outcrops in the valley are but rarely seen. There is an old limekiln on the land of John Olcott a short distance north from Wurtsboro located near the outcrop of the Esopus shales. There is however no outcrop of limestone in the vicinity, the rock used for burning lime being gathered from the fields.

Just over the county line north from Spring Glen station[1] in Ulster county, there is an old quarry near the east bank of the now abandoned Delaware and Hudson canal. The rock as here exposed is a thin bedded limestone with some layers of shale and appears to belong to the lower portion of the Manlius.

Two miles southwest from Ellenville there is a small but conspicuous outcrop of Helderbergian limestones which rise above the general level of the valley. The outcrop is near Sanborn creek on the land of L. F. Hall. Lime is burnt at this place but only in small quantities. A similar outcrop is seen at John Hornbeek's quarry a short distance south of the Eastern Reformatory

[1]This outcrop and the two following are noted by Mather. Geol. N. Y. 1st Dist. 1843. p. 322-33.

at Napanoch. The presence here of Leptaenisca adnascens Hall & Clarke is indicative of the New Scotland age of these beds.

In passing northward from Ellenville the first outcrop favorable for the examination of the Cobleskill is on the land of Joseph Chipp ¼ mile north from Kerhonkson. The rock is shown in the base of an old quarry on the left of the highway leading to Accord. The locality is not favorable for collecting but the following fossils were obtained.

1 Favosites helderbergiae *var.* praecedens *Schuchert*
2 Atrypa reticularis *Linné*
3 Orthothetes interstriatus *Hall*
4 Spirifer corallinensis *Grabau*
5 S. *cf.* vanuxemi *Hall*
6 Whitfieldella nucleolata *Hall*
7 Leperditia jonesi *Hall*

The Rondout is not well shown in this section. About 16 feet of Manlius limestone is exposed in the quarry of Lincoln McConnell on the opposite side of the highway. The combined thickness of the Rondout and Manlius at this place is 70 feet.

One of the most favorable localities for the examination of the Decker Ferry and Cobleskill formations is in the cut of the recently constructed Kingston branch of the Ontario & Western Railroad, ½ mile southwest from Accord. The railroad passes in succession over the formations, from the shales underlying the Decker Ferry to the Coeymans limestone which is exposed near the station at Accord, but only the shales, the Decker Ferry and the Cobleskill are shown in the cut. The shales which are exposed in this cut are considered to be of Salina age and are exposed for a thickness of 18 feet. The beds are soft, argillaceous with bands of mineral matter and so far as known without fossils.

The Decker Ferry formation is 12 feet thick and in layers which are quite massive. The basal layer is arenaceous and gradually changes and becomes more calcareous above. The formation is fossiliferous throughout. The red crystalline limestone which forms such a conspicuous layer in the Nearpass section has not been observed here, and whether its absence is due to thinning out or failing through overlap of the succeeding deposits, in which case only the upper part of the Decker Ferry

formation would be represented in this section, has not been determined. It seems probable that since the period was one of submergence, the latter view is more nearly correct, though in this section Chonetes jerseyensis, which is the characteristic fossil of the lower Decker Ferry formation in the Nearpass section, is here equally as abundant and in size averages larger. This fossil, in the cut at Accord, is sometimes so plentiful as to make a band a fraction of an inch in thickness. From the railroad cut the following species were obtained.

1 Favosites *sp.*
2 Monotrypa corrugata *Weller*
3 Rhynchonella? lamellata *Hall*
4 A. reticularis *Linné*
5 Chonetes jerseyensis *Weller*
6 Rhipidomella *cf.* preoblata *Weller*
7 Rhynchonella deckerensis *Weller*
8 R. litchfieldensis *Schuchert*
9 Spirifer *cf.* corallinensis *Grabau*
10 Spirifer *sp. undet.*
11 Stropheodonta bipartita *Hall*
12 Pterinea emacerata *Hall*

A favorable place for the collection of fossils from the basal arenaceous layer is at Fiddlers Elbow on the Delaware and Hudson canal a short distance from the railroad cut. At this place the canal is partly excavated in the shales and the limestone is found a little higher up by the canal bank. At some points the underlying shales have weathered away leaving the limestone above as a slightly projecting ledge. From the basal arenaceous layer the following species were obtained.

1 Favosites *sp.*
2 Monotrypa corrugata *Weller*
3 Atrypa reticularis *Linné*
4 Gypidula *cf.* galeata *Dalman*
5 Stropheodonta bipartita *Hall*
6 Spirifer *sp.*

At this place a number of rather poorly preserved specimens of a pentameroid were found. They approach closely Gypidula galeata of the Coeymans limestone and may prove to be identical with it.

The Cobleskill limestone is exposed a little higher near an old limekiln. The rock is here much weathered and fossils are readily obtained though not in a well preserved state. A feature of the collection from the Cobleskill obtained at this point is the large number of gastropods and cephalopods found, and the fauna is more nearly like the normal fauna of the Cobleskill of Schoharie county than at any other section that has been studied

in eastern New York. Ilionia sinuata not recorded from the Cobleskill farther southwest and in the Nearpass section is quite abundant here. The following species were obtained.

1 Favosites *sp.*
2 Atrypa reticularis *Linné*
3 Rhynchonella? lamellata *Hall*
4 R. litchfieldensis *Schuchert*
5 Whitfieldella nucleolata *Hall*
6 Ilionia sinuata *Hall*
7 Bellerophon auriculatus *Hall*
8 Kionoceras darwini *Billings*
9 Orthoceras (large)
10 Leperditia jonesi *Hall*
11 Calymmene camerata *Hall*

In the railroad cut the Cobleskill is also exposed but not so favorably for collecting as in the last named locality. The thickness in the cut is about 6 feet. The contact with the Rondout could not be observed at this station. The formations exposed at Fiddlers Elbow and in the railroad cut can be readily traced to a short distance east of Accord, where they form a clearly defined cliff. The base of the cliff is mostly covered with talus and the outcrops are not favorable for collecting.

In the vicinity of Accord no beds suitable for making cement have been observed. This place is but 6 miles from High Falls where cement has been quarried from the dark Rosendale beds which at the latter place have a maximum thickness of 22 feet. It will thus be seen that the lower cement bed so extensively developed in the Rosendale region and which extends to High Falls, becomes too calcareous to be used for cement before Accord is reached. At Rosendale the lower cement bed, with the exception of Leperditia, which is sometimes found near the base, is so far as known, entirely without other fossils. When however High Falls is reached the cement bed, specially near its base, becomes fossiliferous. From the cement rock at this place some corals, Atrypa reticularis Linné, Ilionia sinuata Hall, and Nucleospira cf. ventricosa Hall have been obtained. The Cobleskill can be readily recognized near the brink of the falls on both sides of the stream. The cement bed is about 14 feet thick, and at its base and resting on the quartzites below, is a fossiliferous band of shaly limestone 4 to 10 inches thick, in a previous report[1] referred to the Wilbur limestone, which in the type section, as at High Falls, underlies

[1] N. Y. State Paleontol. An. Rep't. 1903. p.1146.

the lower cement bed. A good view of the falls is given by Darton[1] in his report on the Geology of Ulster county. At High Falls the thin layer above referred to contains unmistakable Decker Ferry species, the most characteristic of which is Monotrypa corrugata Weller. The fauna obtained follows:

1 Favosites *sp.*
2 Monotrypa corrugata *Weller*
3 Atrypa reticularis *Linné*
4 Pterinea emacerata *Conrad*
5 Orbiculoidea *cf.* tenuilamellata *Hall*
6 Orthoceras *sp. undet.*

The study of the sections at High Falls and Accord and a comparison of them with the sections farther south indicate quite clearly that the lower cement bed at Rosendale and the lower cement bed and Wilbur limestone at High Falls are of the same age as the Decker Ferry formation as developed to the southwest of these localities. It is also believed that the cement bed which holds the stratigraphic position of the Bertie waterlime of western New York is of the same relative age as the latter, both underlying the Cobleskill limestone. In western New York the Bertie limestone is characterized by an Eurypterus fauna. The absence of Eurypterus from the formation in eastern New York is attributed to the fact that this section of the State belonged to another sea-province. We therefore propose to meet this difference in the east by introducing for the lower cement bed in Ulster and adjoining counties the term Rosendale cement. The transition to the Cobleskill from the underlying fossiliferous beds in eastern New York has been shown. In western New York the transitional features are somewhat more complex and obscure. Still enough is known to show an intimate relationship between the Cobleskill and Bertie formations.

In the Eurypterus-bearing waterlime beds of western New York (Bertie) Cobleskill fossils are rarely found associated with Eurypterus. However Orthothetes interstriatus Hall and Leperditia scalaris Jones are occasionally found on the same slab with Eurypterus. In beds which are strictly referable to the Cobleskill and which contain Cobleskill fossils the writer has never found an Eurypterus. The condi-

[1]N. Y. State Geol. 13th An. Rep't. 1894. pl. 10 facing p.342.

tions however which are found and which show the intimate relation of the two formations are as follows.

In western New York usually underlying the Oriskany sandstone is found the Cobleskill dolomite which at Buffalo, Dr Grabau[1] has shown, contains a fauna similar to the Cobleskill and which later studies have shown to be identical with the Cobleskill. In Ontario county at Phelps below the Oriskany sandstone is found the Cobleskill or "bullhead" rock as it is known in western New York. This rock here and farther west at Victor and beyond, contains the Cobleskill fauna. Beneath the "bullhead" rock in Ontario county in a thin bed of waterlime, fragments of Eurypterus are found and at Victor a large number of fragments from this horizon were obtained. Beneath this layer of waterlime in Ontario county we find again in the dolomite layer another Cobleskill or "bullhead" fauna in which Lichas ptyonurus Hall is found and Cyathophyllum hydraulicum Simpson is quite abundant. Beneath this second dolomite layer containing Cobleskill fossils, waterlime beds again occur in which Eurypterus are found.

From the above conditions it would appear that while the Decker Ferry fauna was living in eastern New York the Eurypterus fauna was still to be found in the Salina sea in the western part of the State, and that there were invasions from the eastern sea which at first were only temporary, but which finally caused the retreat or destruction of the Eurypterus fauna.

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[1]Geol. Soc. Am. Bul. 1900. 11:363.

TABLE SHOWING RELATIONS OF THE ONTARIC OR SILURIC SECTIONS OF NEW YORK AS DEVELOPED ON BOTH SIDES OF THE HELDERBERG

MISSISSIPPIAN SEA				HELDERBERG	CUMBERLAND BASIN		
Buffalo	Ontario county	Herkimer county	Schoharie county	Albany county	Rondout	High Falls	Port Jervis
Oriskany	Oriskany	Coeymans	Coeymans	Coeymans	Coeymans	Coeymans	Coeymans
		Manlius	Manlius	Manlius	Manlius	Manlius	Manlius
		Rondout	Rondout	Rondout	Rondout	Rondout	Rondout
Cobleskill	Cobleskill	Cobleskill	Cobleskill		Cobleskill	Cobleskill	Cobleskill
Salina	Salina	Salina	Salina		Salina	Salina	Salina
Bertie	Bertie	Bertie			Rosendale	Rosendale	Decker Ferry
Camillus	Camillus	Camillus			Wilbur	Wilbur	
	Syracuse					Binnewater quartzites	Bossardville Poxino Island
Vernon	Vernon	Vernon				High Falls shales	High Falls shales?
Pittsford (?)	Pittsford						
Guelph	Guelph						
Lockport	Lockport	Lockport					
Rochester	Rochester	Rochester ?				Shawangunk	Shawangunk
Clinton	Clinton	Clinton					
Medina	Medina	Medina					
Oswego	Oswego	Oneida					
Lorraine	Lorraine	Lorraine	Lorraine	Lorraine	Normanskill ?	Normanskill ?	Normanskill ?

EXPLANATION OF PLATES

PLATE 1

Carabocrinus geometricus sp. nov.

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1 View from posterior interradius. x4

2 View of tegmen showing the straight line on which the radials meet and the acute angle at both ends as if for the insertion of a triangular deltoid. The angles in the figure are not all as acute as in the specimen. x4

Malocystites emmonsi sp. nov.

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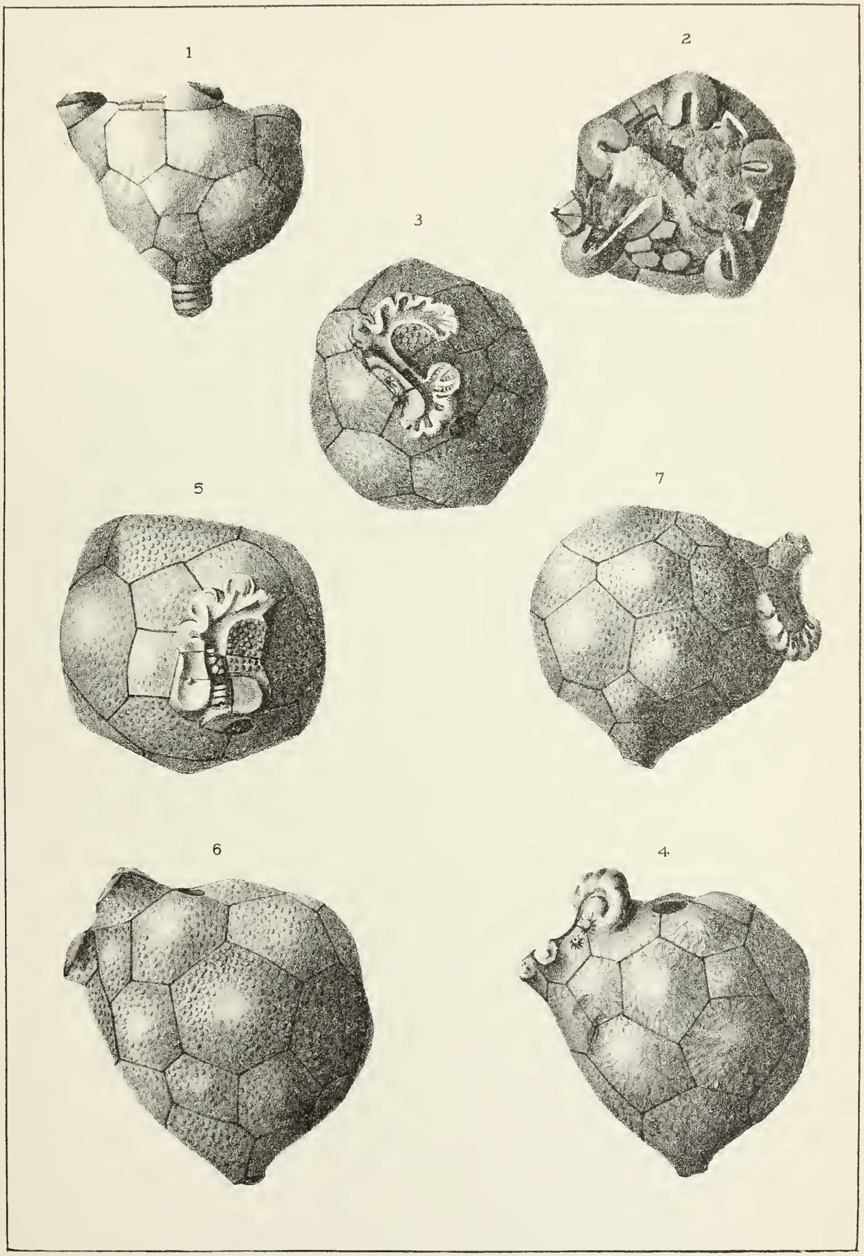
3, 4 Oral and side views of specimen A, the type. Figure 4 shows clearly the position of the genital pore and madreporite. The axis used in the description is here the vertical axis of the figure x4

5, 6 Oral and side views of specimen B. x4

7 Specimen C, a form with the sigma much nearer the stem. x4

Rep Paleontologist 1903 Plate 1.



G S Barkentin del. W S Barkentin lith.

PLATE 2

Rhaphanocrinus gemmeus sp. nov.

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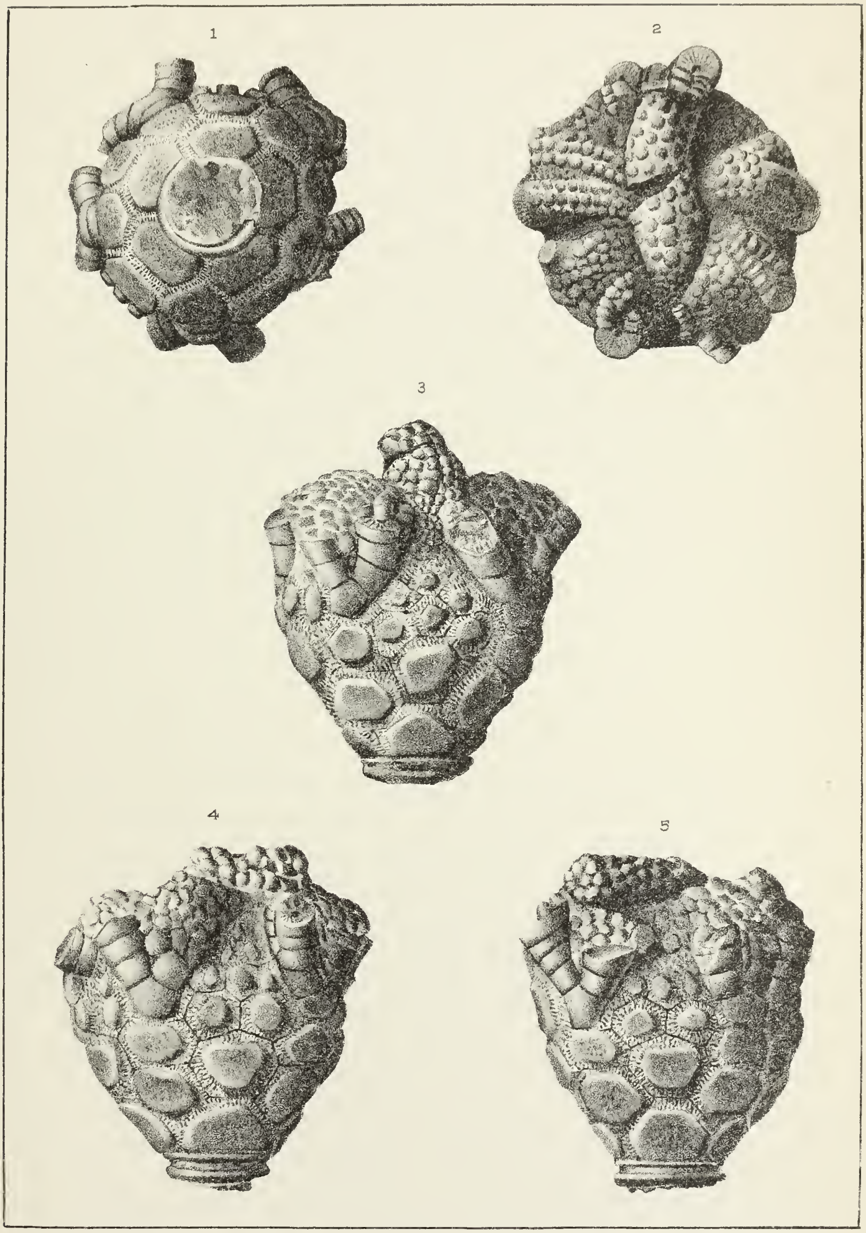
1 View of base. x4

2 View of oral surface with anal tube

3 View of posterior interradius. x4

4 View of right posterior interradius. x4

5 View of left anterior interradius. x4



G.S.Barkentin.del. W.S.Barkentin.lith.

PLATE 3

Lyriocrinus beecheri sp. nov.

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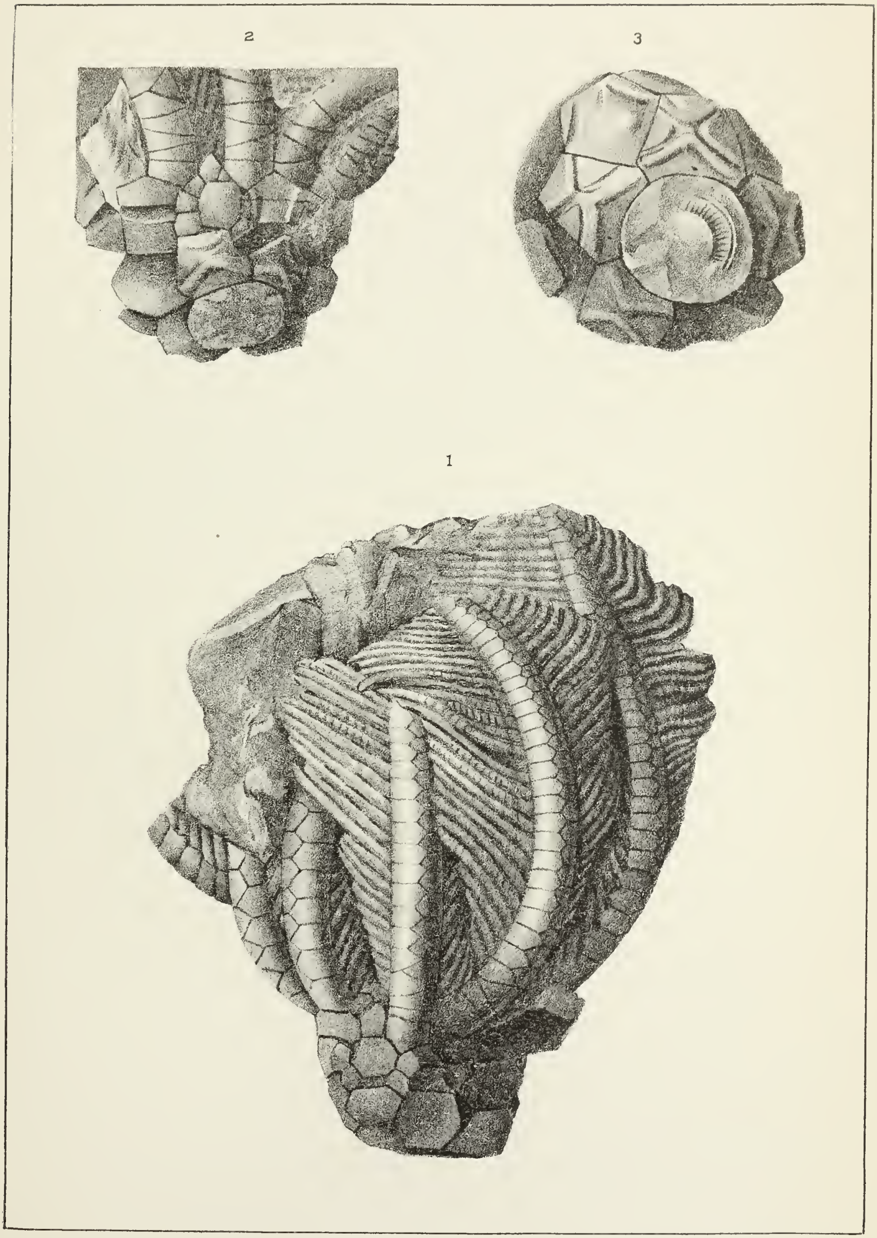
1 View with the vertical interradius of figure 4 (text) a little to the left. x4

2 View showing lower left interradius of figure 4 (text). x4

3 View of base showing in part the plate ridges. x4



G. S. Barkentin, del. | W. S. Barkentin, lith.

PLATE 4

Subulites raymondi sp. nov.

Page 293

1, 2 Views of the type specimen. x4

Holopea microclathrata sp. nov.

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3 View of the type specimen. x4

4 A portion of body whorl of same. x12

Eunema historicum sp. nov.

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5 View of the only specimen found. x4

Eunema epitome sp. nov.

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6, 7 Different views of the only specimen found. x4

Modiolopsis subquadrilateralis sp. nov.

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8, 9 Different views of the type specimen. x4

Cyrtodonta? lamellosa sp. nov.

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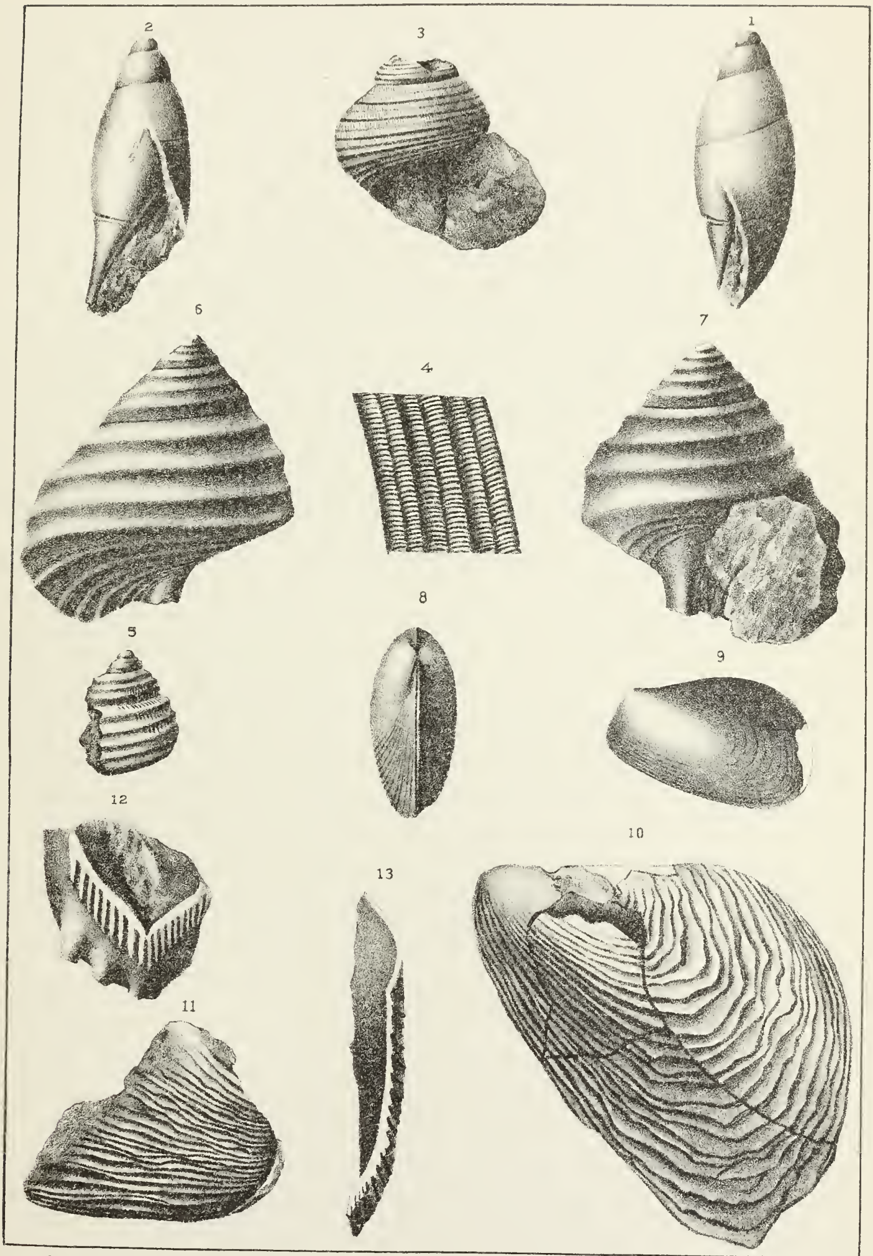
10 View of left side of type specimen. x3

11 Anterior portion of shell of same specimen, viewed from right side. x4

12 View of broken edges of the valves about the middle of the ventral margin to show the relative size and arrangement of the lamellae. The right valve here incrusted by a bryozoan. x4

13 Fractured margin of valve showing thickening as posterior margin is approached. x4

CHAZY FOSSILS



G S. Barkentin. del.

W S. Barkentin. lith.

PLATE 5

Cheirurus mars sp. nov.

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1, 2 Views of the type specimen. x2

Eunema altisulcatum sp. nov.

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3 View of the type specimen. x4

Straparollina harpa sp. nov.

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4, 5 Views of two specimens. x4

Schizambon duplicimuratus sp. nov.

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6, 7 Pedicle valves of two specimens. x4

Syntrophia multicosta sp. nov.

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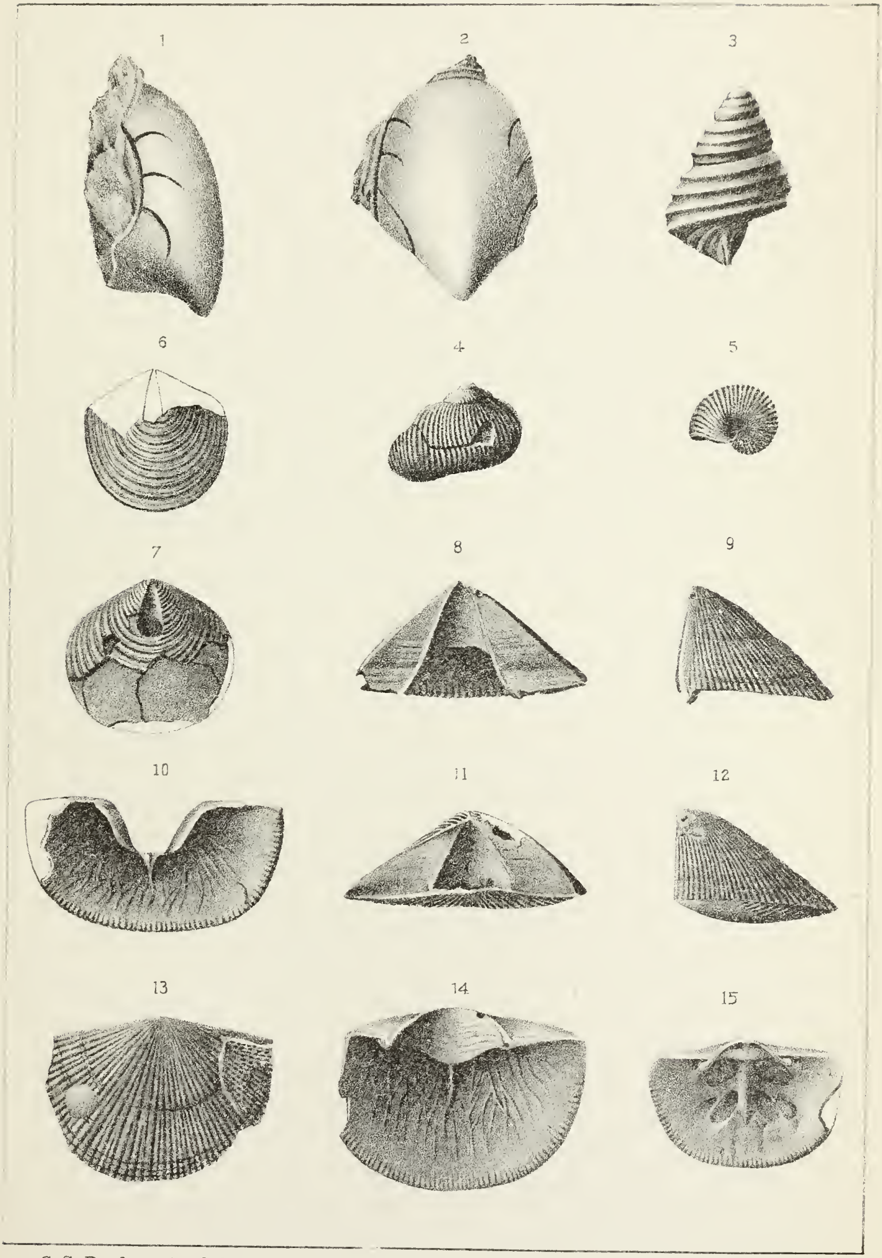
11, 12 Two views of the type specimen. x2

8–10, 14 Different views of the pedicle valve of another specimen. x2

13, 15 External and internal views of different brachial valves. x2



G.S. Barkentin, del. W.S. Barkentin, lith.

PLATE 6

Cameroceras (Proterocameroceras) brainerdi Whitfield (sp.)

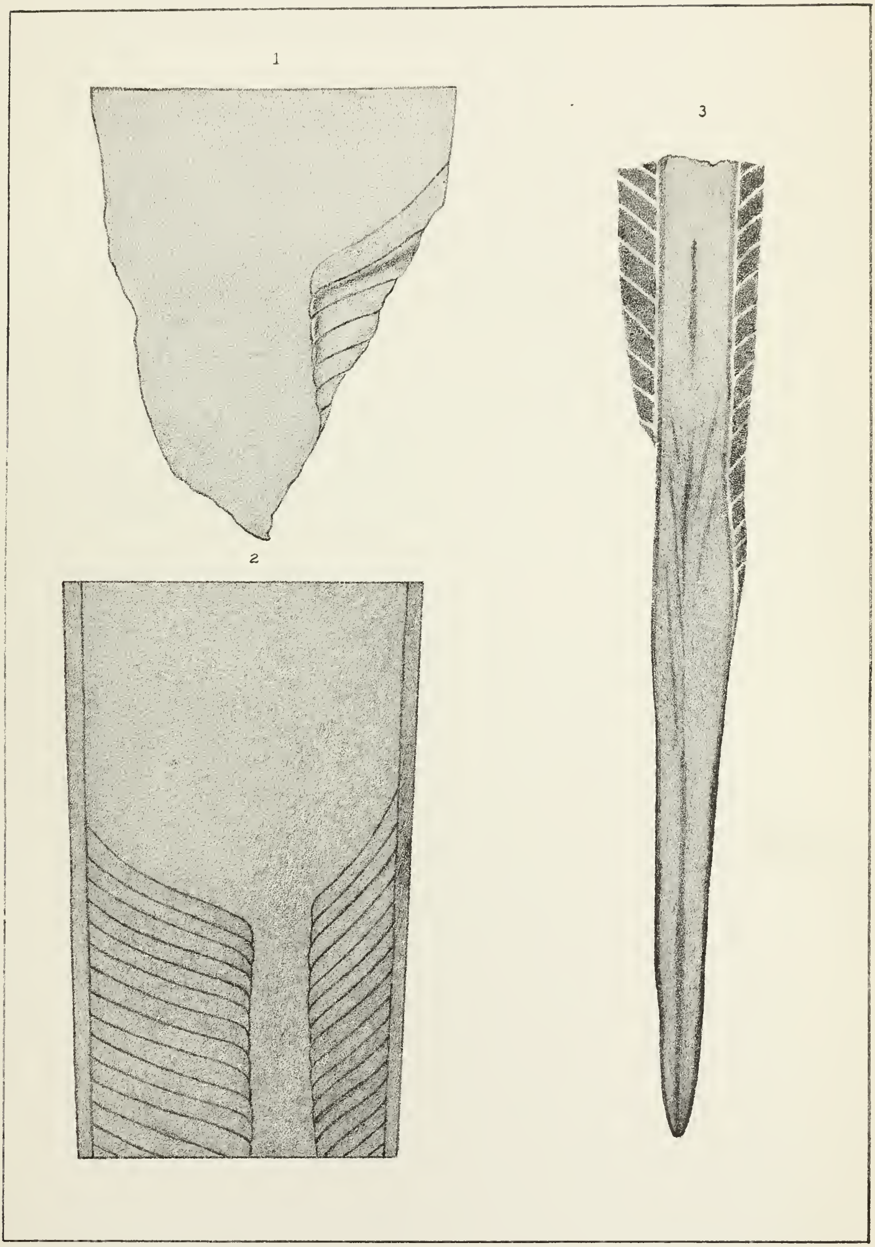
1 Natural section of fragment showing the passage of the siphuncle into the living chamber and the absence of the endosipholining in the anterior part of the siphuncle (endosiphocylinder). Natural size

2 Natural (slightly oblique) section through posterior part of living chamber and anterior part of the endosiphocylinder, showing the structure of the ectosiphuncle (length of septal necks and absence of endosipholining). Natural size

3 Natural section of nepionic bulb and posterior part of phragmocone, showing the length and form of the nepionic bulb, the slight constriction at the beginning of the phragmocone (where on the right side the first four small septa are left out in the drawing); the cicatrix at the apical end, the endosipholining, the endosiphotube and some of the endosiphosheaths. Natural size

Originals from the Beekmantown limestone at Valcour N. Y.

CEPHALOPODS



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 7

Cameroceras (Proterocameroceras) brainerdi Whitfield (sp.)

1 Natural longitudinal section of part of siphuncle, showing the broad black conchiolinous endosiphocoleon at the upper end (esco) and the sections of the wings (w), separated by the endosiphosheaths. At the lower end a posterior transverse section of the fragment, with broad flat endosiphocoleon (esco) and the embracing wings (w) is figured. x2

2 Further enlargement of the endosiphocoleon of figure 1 (x4), to show the central thickening of the endosiphocoleon which leads to the formation of the endosiphotube

3–10 A series of transverse sections (except figure 4) through the farther posterior continuation of the fragment reproduced in figure 1. All x2

3 Shows, like all the farther sections, the endosipholining, the central endosiphocoleon, one complete pair and half of a second one, of crescent-shaped sections of wings

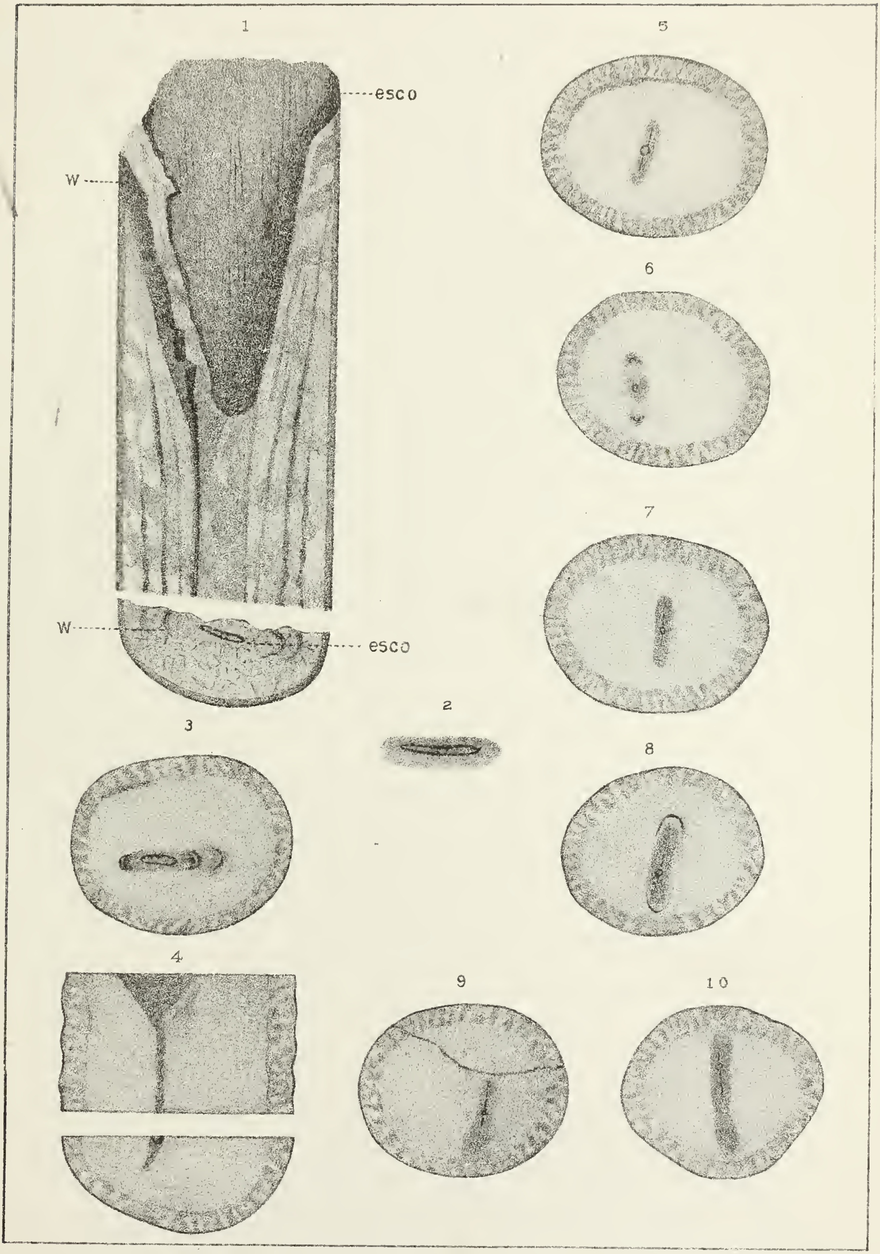
4 Upper figure, longitudinal section of a block (x2) to show a sudden turn of the endosiphocoleon and lower figure, transverse section of farther end of the same block

5 Shows the endosiphotube inclosed within the endosiphocoleon which has been reduced to a double plate

The following figures 6–10 illustrate the apicad reduction of the diameter of the endosiphotube and the gradual disappearance of the endosiphocoleon (the lithographer has shaded this organ too dark in figures 9 and 10, and notably so the lower half in figure 10, as well as the interspaces between the endosipholining and the endosiphocoleon). The apparent wabbling of the endosiphocoleon from the left to the right side in these sections is due to the fact that some are drawn from the anterior and others from the posterior ends of blocks.

Originals from the Beekmantown limestone at Valcour N. Y.

Rep Paleontologist 1903 Plate 7



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 8

Cameroceras (Proterocameroceras) brainerdi Whitfield (sp.)

1 Natural longitudinal section of part of siphuncle of young specimen, showing matrix filling, smooth endosiphocone and continuation of the latter with the endosiphocoleon cut through its minor axis. Natural size

2 Longitudinal section of fragment of siphuncle, showing uninterrupted continuation of endosiphocoleon (cut through its minor axis) and an endosiphosheath. The upper transverse section shows half of the endosiphocoleon and two wings. Natural size

3 Natural longitudinal section of fragment of young siphuncle, retaining the matrix filling of the endosiphocone, which shows an undulating outline. Natural size

4 Transverse section of young siphuncle, showing the endosiphoblades and endosiphotubes. x2

5 Transverse section of siphuncle, showing endosiphotube, three endosiphoblades and endosipholining. x3

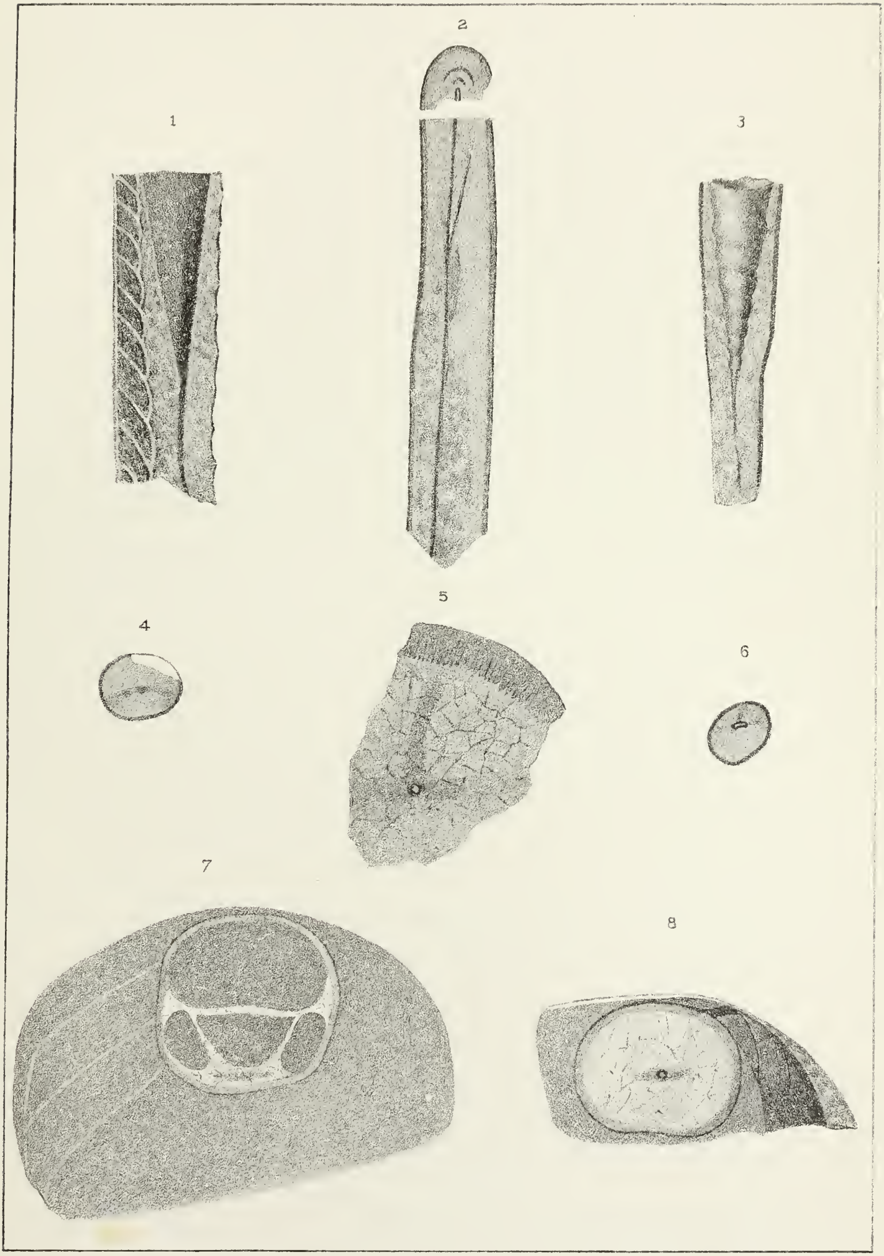
6 Transverse section at posterior end of fragment reproduced by figure 3, showing young endosiphocoleon and three endosiphoblades. Natural size

7 Natural transverse section of shell, showing the siphuncle with the section of the endosiphocone (in the center) and the three calcareous endosiphoblades fastening it to the ectosiphuncle (two situated laterally and one below) leaving cavities between them, which are filled with matrix. For comparison with figures 5 and 6 the figure should be inverted. x2

8 A section of the same specimen, situated farther apicad and showing the endosiphotube and rapid disappearance of the endosiphocoleon. These parts are less distinct in the specimen than in the drawing. x2

Originals are from the Beekmantown limestone at Valcour N. Y.

CEPHALOPODS



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 9

Cameroceras (Proterocameroceras) brainerdi Whitfield (sp.)

1 Natural longitudinal section of fragment of siphuncle, showing in upper part fragment of outer surface of siphuncle with forward curving of septa; in middle part the white calcite layer of an endosiphosheath, flanked on both sides by wings (w) and in the lower part the endosiphocoleon (esco). x2

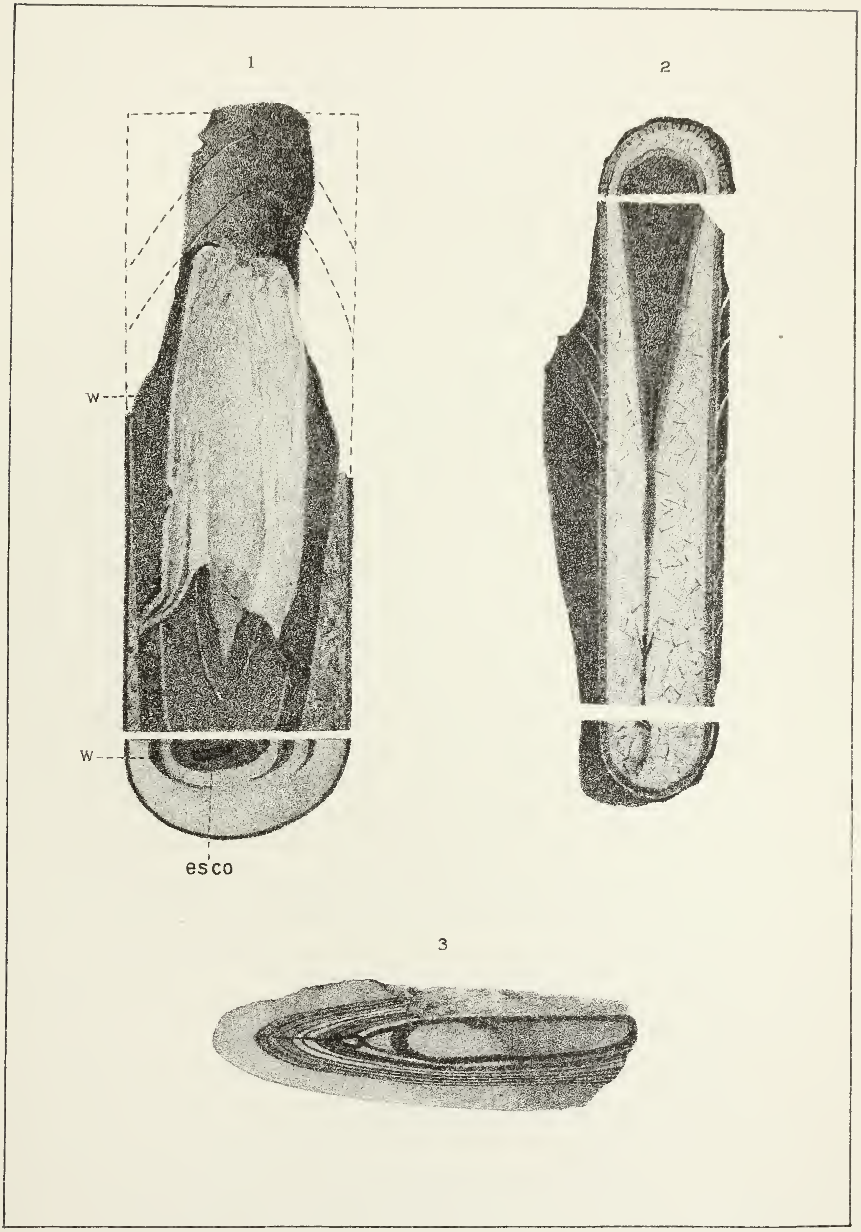
2 Longitudinal section through a siphuncle, showing the endosiphocone with its bounding endosiphosheath in the anterior part and the endosiphocoleon (cut through the minor axis) forming in the posterior part of the endosiphocone. There are also shown farther apicad the bases of the other endosiphosheaths and in the posterior transverse section the lateral end of the endosiphocoleon and an endosiphoblade, extending obliquely from the same to the endosipholining. x2

Originals from the Beekmantown formation at Valcour N. Y.

Piloceras explanator Whitfield

3 A transverse section through the posterior part of the siphuncle (the shaded part at the right hand side is obliquely cut forward), showing the closely arranged endosiphosheaths; among them the last (darker, innermost) endosiphosheath and an endosiphofunicle (cut obliquely) extending at the left from the lateral side of the endosiphocone. x2

Original from the Beekmantown formation at Valcour N. Y.



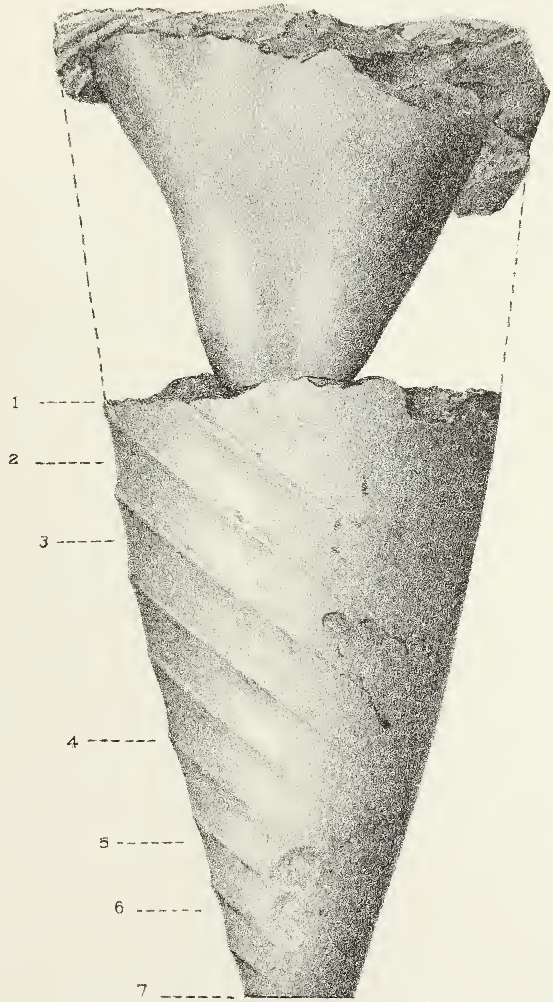
G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 10

Piloceras explanator Whitfield

A nearly complete siphuncle showing above a cast of the endosiphocone covered by the last endosiphosheath [*see* pl.13, fig.1] and below the exterior of the siphuncle with the very obliquely passing fracture lines of the septa along their flexures in the endosiphuncle. The numbers correspond to the sections made through this siphuncle and reproduced on plate 11. Natural size

The original from the Beekmantown beds at Fort Cassin Vt. (collected by C. Rominger 1888)



G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 11

Piloceras explanator Whitfield

1–7 Transverse sections through the siphuncle, figured on plate 10. Natural size

1 Showing the more distant earlier endosiphosheaths and more closely arranged last endosiphosheaths (of adult individual) and the endosiphofunicles.

2 The small flat endosiphocoleon in the center and a well developed system of endosiphofunicles extending from the first endosiphosheath to the outer wall. At the right hand side an endosiphofunicle, which is branching several times in outward direction (enlarged on plate 12, figure 1).

3 Shows another distinctly branching endosiphofunicle on upper side (enlarged on plate 12, figure 2), which well exhibits the relation of the endosiphosheaths to the endosiphofunicle.

4–6 Show the decrease in the number of endosiphosheaths (by resorption or alteration in calcite?) and of the endosiphofunicles in apical direction.

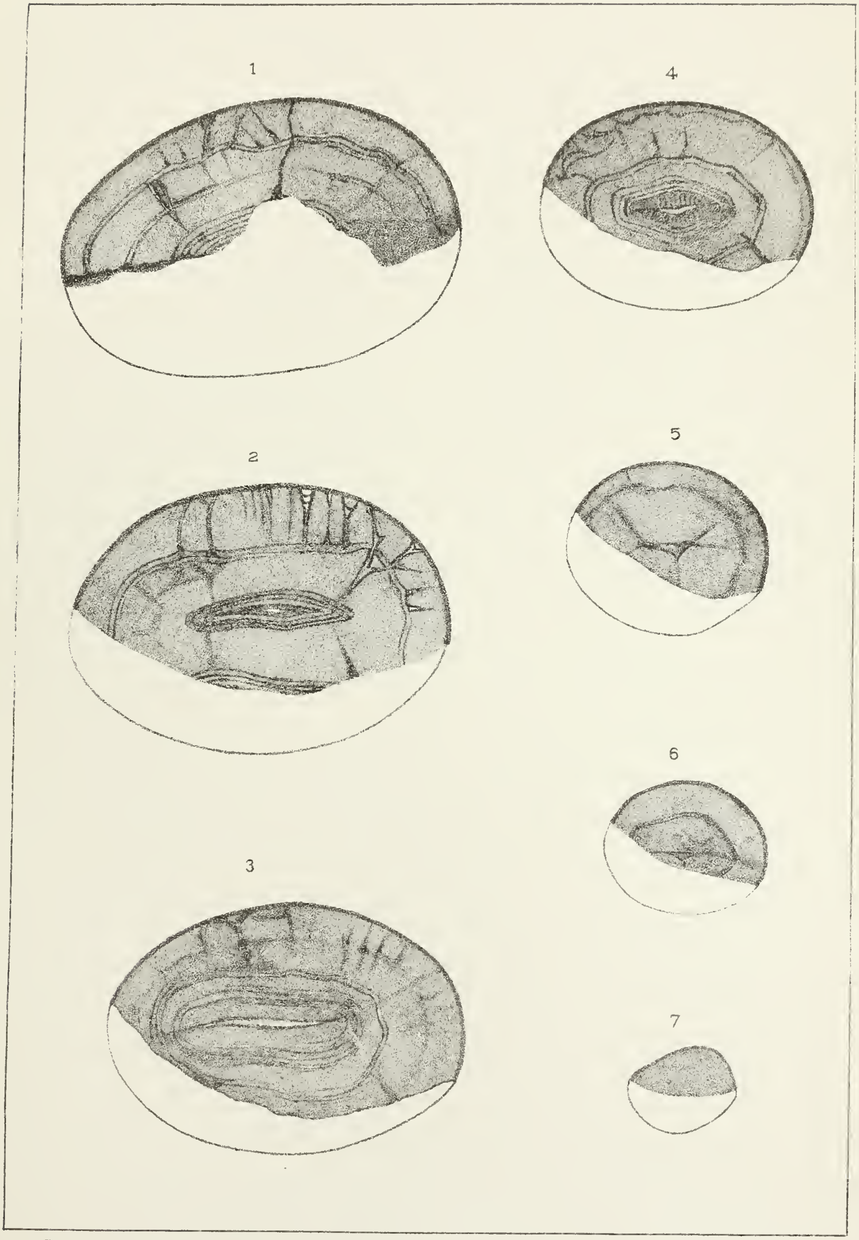
4 This section shows at the lower right hand side an endosiphofunicle which distinctly passes through an endosiphosheath that is bent outward at the point of intersection (enlarged on plate 12, figure 4).

5, 6 Endosiphofunicles springing here principally from the corners of the endosiphocoleon.

7 The endosiphocoleon is not any longer shown since the center of the siphuncle is here worn away.

Originals from the Beekmantown beds at Fort Cassin Vt.

CEPHALOPODS



G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 12

Piloceras explanator Whitfield

1 Enlargement of endosiphofunicle (part of section 2 of plate 11), showing its threefold branching and the angulation of the endosiphosheaths at the points of intersection with the endosiphofunicle resulting from the suspension first of the outer endosiphosheath by means of the endosiphofunicle and later continuation of the latter to the next younger (more interiorly situated) endosiphosheath. x3

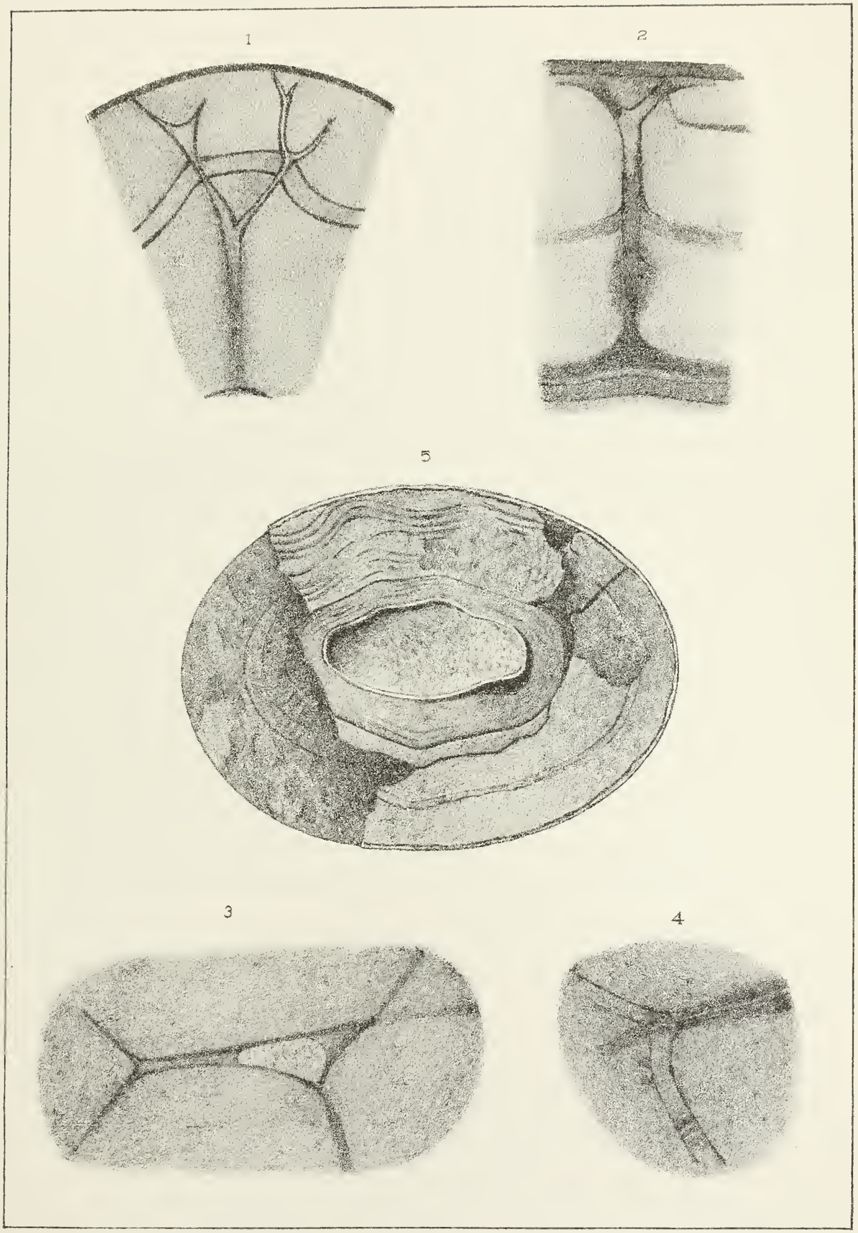
2 Shows similar features (enlargement of figure 3 of plate 11) of an endosiphofunicle, extending through two or more endosiphosheaths. x5

3 Endosiphocoleon with its suspending endosiphofunicles (enlargement of center of figure 5 on plate 11). x5

4 Enlargement of part of figure 4 on plate 11, showing the angulation of the endosiphosheath at the point of its intersection with the endosiphofunicle. x5

5 Natural, slightly weathered transverse section of a siphuncle, showing the undulating character of the endosiphosheaths, probably due to endosiphofunicles. Natural size

Originals of figures 1–4 from the Beekmantown beds of Fort Cassin Vt.; of figure 5 from the same beds at Valcour N. Y.



G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 13

Piloceras explanator Whitfield

1 Lateral view of the endosiphocone of the specimens figured on plate 10. Natural size

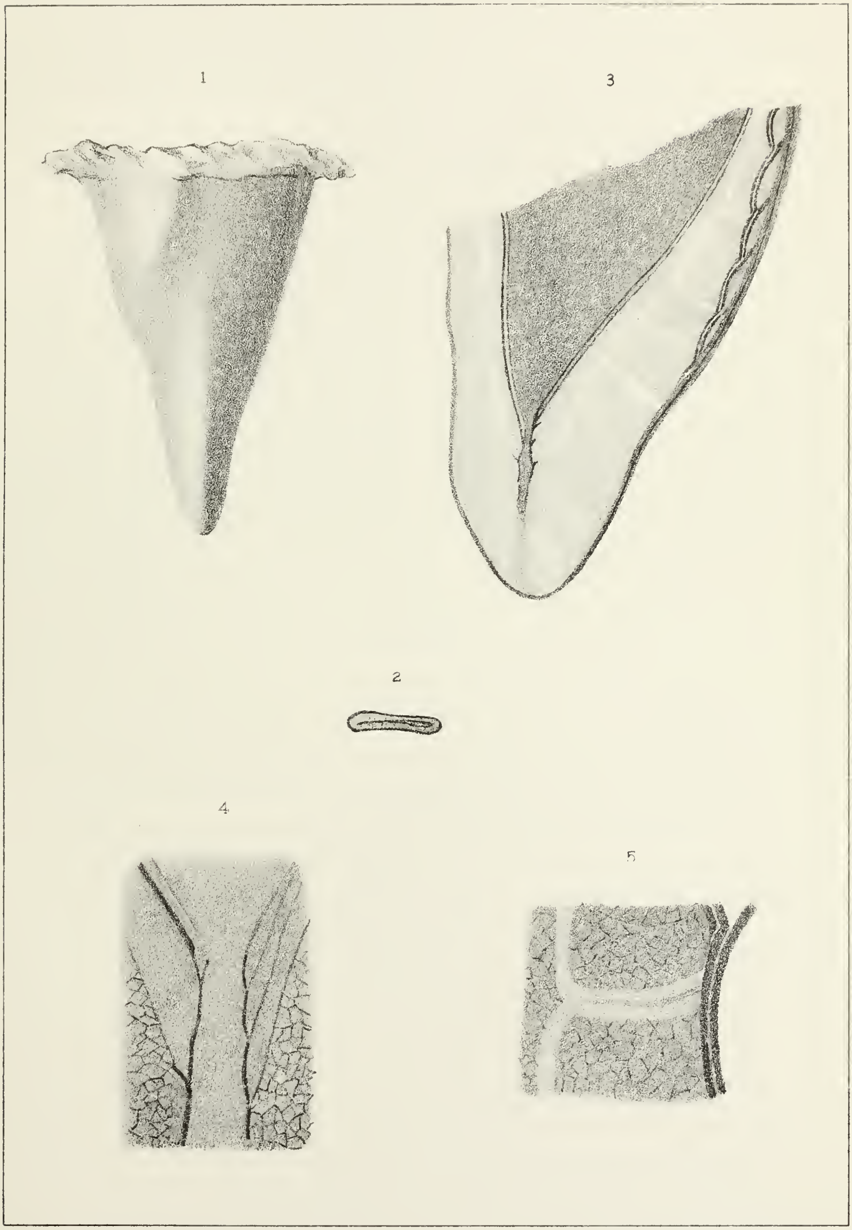
2 Section close to the apical end of the latter showing the last endosiphosheath and the internal conchiolinous lining of the same (endosiphocoleon). Natural size

3 Longitudinal section of a siphuncle, showing the endosiphocone filled with dark matrix and bounded by the last endosiphosheath; the swelling of the apical part indicative of a nepionic bulb; the cameras on the right hand side and the endosiphofunicles as white bands extending from the endosiphosheath to the ectosiphuncle (enlarged in figure 5). The endosiphocoleon is cut (somewhat obliquely) through its minor axis and shows its dark (more or less conchiolinous) wall, extending to the point of its passage into the endosiphocone.

4 The same. Enlargement (x5) of the section of the endosiphocoleon

5 The same. Enlargement (x5) of an endosiphofunicle, to show its connection with the endosiphosheath (on left hand side) and with the ectosiphuncle (on the right hand side). The figure shows also the extension of the septal neck in the ectosiphuncle beyond the preceding septum.

Rep Paleontologist 1903 Plate 13



G. S. Barkentin, del. W. S. Barkentin, lith.

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Zoology 10

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FREDERICK J. H. MERRILL Director

Bulletin 71

ZOOLOGY 10

FEEDING HABITS AND GROWTH

OF

VENUS MERCENARIA

BY

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University of the State of New York

New York State Museum

Frederick J. H. Merrill Director

Bulletin 71

ZOOLOGY 10

FEEDING HABITS AND GROWTH

OF

VENUS MERCENARIA

Introduction

In a previous bulletin of the New York State Museum,[1] attention was directed to the fact that both the hard clam, or little-neck, and the common long-neck clam were rapidly diminishing in numbers, not only in the waters of New York State, but also along the entire Atlantic coast where these forms have previously been found. After a careful examination of a large part of the coast of New England and Long Island, it appeared that the apprehensions of many market men and clammers concerning the growing scarcity of these forms were well founded. It was not intended that the attitude of an alarmist should be assumed. Clams still may be had at almost any hotel or restaurant. Even if the natural beds alone are depended on, as heretofore, a certain supply may be had for some time. But it is certainly true that, unless something is done to check or modify the indiscriminate and unintelligent methods of taking these forms now in vogue, the supply is finally to fail more or less completely everywhere, as it has already failed in many localities. That time is not remote. It is difficult for one not personally familiar with the clam flats and beaches, and their histories, to realize the truth of such a statement. While at any time one may obtain fresh or canned lobsters in the market, it is difficult to interest him by the statement that he may not long be able to

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1 Clam and Scallop Industries of New York State. N. Y. State Mus. Bul. 43.

indulge his taste for them; yet even now lobsters are dangerously near extinction on our coast. But it is the consumer who should be interested, if possible, because from him, through his representatives in the Legislature, must come the action which shall make possible new and intelligent methods of propagation which may preserve the supply.

Unpleasant facts of this kind, in any case, should be considered seriously by the public-spirited citizen; but his interest would be enlisted, and his support obtained much more readily, if he could be shown some practical way out of the difficulty.

It has been proved, I think beyond question, that, not only are methods of cultivating the common clam, *Mya arenaria*, easy and inexpensive, but the results of the labor involved are astonishingly great. "Seed" clams may readily be obtained in many localities. They may, when necessary, be transported from one place to another without injury. The planting is a simple process. Small individuals may even be sown broadcast on a soft bottom like so much grain. Unlike the oyster, the salinity of the water makes little difference with their growth. Most important of all, their growth is extremely rapid.

This method of culture, the details of which have been carefully worked out and tested in artificial beds, was developed after a study of the life history, the habits, and the conditions of growth. Everything of scientific interest concerning the form has not been investigated. The early stages of development from the egg, for example, are not yet known; but enough was known to devise an entirely satisfactory and practical method of culture, and this method has been thoroughly tested.

The question may be asked, why, if the demand is increasing and prices are rising, if the supply has everywhere fallen off, and if a cheap and practical method of culture has been devised, do not those who are interested in supplying the market become clam "farmers," instead of remaining clam-diggers?

The answer is that ancient laws still leave beaches and flats to the people. They are public grounds where all have equal rights. On them any one may dig at any time. No man has a right to plant and protect his clams, and clam culture is impossible. To

repeal a law of this character is extremely difficult, for it appeals to the many as a cession of their rights to the privileged few. But all would have equal rights to the property by lease or purchase. Good beaches are very numerous, and there is little danger that any would be excluded who might desire such property. The sale and lease of bottoms to oystermen along the shores of Long Island, have apparently worked injustice to no person who is desirous of entering that occupation. At a very few points on the coast, portions of flats have been leased to clammers. These experiments have failed because of a lack of adequate protection. Unless such a system, with proper protection, is introduced by the repeal of old, and the enactment of new laws, soft clam culture will be impossible, and such laws can be had only when they are desired by the people at large.

The little-neck clam, *Venus mercenaria*, grows most abundantly below the low tide line, where it is taken by means of tongs. Much of the shallow bottom about Long Island, in which clams were formerly taken, has been leased to oystermen. The profit from oyster culture is much greater, acre for acre, than that derived from the taking of hard clams, which are left to propagate by the natural method. The areas left to clammers are now limited, and the greater part of the supply used in the canning industry comes from the southern coast. At the same time, clams are rapidly diminishing in the available beds.

The little-neck is also found between tide lines. This fact suggested experiments to determine whether they grow well in such places. Beaches and flats are not now generally available by lease. If this were given, these areas could be more easily protected than those in deeper water, and the matter of planting and digging would be greatly simplified. It is of the utmost importance, however, that clams not continually submerged should increase in size with some degree of rapidity, to insure the success of culture methods under these conditions. An account will be given of this growth in Venus.

Very little is known of the growth of lower organisms. Among the Lamellibranchiata, the group of mollusks to which the clams belong, much is known concerning the growth of the oyster, which, for many years, has been artificially reared in Europe and

America. But, till very recently, no observations have been made on the growth of any clam. In work for the United States Fish Commission, the results of which have not yet been published, Mya was reared in many places, the experiments being carried out on a large scale. In many ways the results were astonishing, particularly in regard to the rapidity of growth. Not only was the actual amount of growth observed, but also the conditions under which it was least and most rapid, or altogether impossible. It was my desire to continue the same line of work with Venus, as nothing was known concerning its growth or the conditions governing it. Though from lack of time and facilities, these experiments were not extensive, they were most encouraging, and show that this form also increases in size rapidly, even when exposed at low tide.

Feeding habits of Venus. Growth a matter of food

Within wide limits, rapidity of growth in clams seems to depend directly on the amount of food. In order to make clear the conditions under which rapid growth is possible, the feeding habits of Venus should be described.

Before such a description is possible, some anatomical features must be noticed. In a clam bed, the animal lies but a short distance below the surface of the bottom. Though the shell is entirely hidden, the creature reaches up to the water above by means of a fleshy extension of the body, which has the form of a double tube. These tubes are known as the siphons, and may quickly be retracted within the valves of the shell. On a smooth bottom, the ends of the siphons may be seen, when the animal is undisturbed, extending out to the level of the surface. A close inspection will show that a steady stream of water is entering one tube [fig. 1, *in. s*] and leaving the other [*ex. s*]. The margin of the first tube is crowned by short, tactile tentacles. When touched by foreign bodies floating in the water, these sense organs cause a closing of the incurrent siphon, or perhaps a retraction of the entire structure. The microscopic diatoms, which form the food of clams, are so small and so evenly diffused in the currents, that they do not induce these movements.

When the animal is removed from the bed, the tight fitting valves of the shell are found to be firmly closed. It may be necessary to break the shell in order to insert a knife blade by means of which the two powerful muscles which connect the valves, and by their strong contraction close them, may be cut. Removing one half of the shell, it is seen that both shell valves are lined on their inner surfaces by thin, fleshy flaps which grow out from the sides of the body. These are known as the mantle folds [*fig.* 1, *m*], and they inclose a large space, the mantle or branchial chamber, in which is found the main part of the body. The body, however, does not entirely fill the mantle chamber, but a large space remains which is filled with water. The siphons are seen to be simply a modified portion of the mantle. It is into this space that the inflowing stream of water, bearing the microscopic food, must enter. The manner in which the food is collected and passed into the mouth will be described presently. While the mantle folds are free at their margins, their edges are closely applied to each other, and the mantle chamber is essentially a closed space, excepting for the siphonal openings.

If now one of these mantle folds be cut away, the body is exposed from the side and appears as represented in figure 1. The mantle fold on the farther side is shown at *m*, lining the entire inner surface of the shell valve, *s*.

Two large, conspicuous folds, *ig* and *og*, the gills, arising from the side of the body, hang free in the mantle chamber. In this position, they are continually bathed by the incoming stream of water, and they perform a very important function in addition to that of the aeration of the blood — that of food collection. Just anterior to the gills, and behind the large anterior adductor muscle, *aa*, are two small folds, *ap* and *pp*, the labial palps. The portion of the palp seen in the figure, *ap*, is simply the lateral extension of a fold which hangs in front of the mouth like a huge lip drawn out to a point on the sides. The posterior palp is similarly placed behind the mouth. The mouth opening is on the median line behind the anterior adductor muscle, and is hidden from view by the closely applied palps. It is a funnellike entrance to the digestive tract, and, because the food of the clam is microscopi-

cally small, it is supplied with no special organs such as teeth or rasping structures.

I would call particular attention to the relation in position between these palps and the anterior edges of the gills; for I wish presently to describe the manner in which food is transferred from gills to palps, and by these into the mouth.

When the gills are removed, there is exposed the main mass of the body [*vm*, fig. 2] which is made up chiefly of a large colored gland, the function of which is the secretion of the digestive fluid, and the greatly developed sexual glands. This body in anatomical descriptions, is called the visceral mass, to distinguish it from the muscular organ which is developed on its under or ventral surface — the so called foot, *f*. The last named organ is represented in the figure as being contracted within the mantle chamber. It is capable of great distension and, in a large clam, may be projected for a distance of two or three inches from the edges of the shell. Though a fleshy structure, it is, when protruded, quite tough and firm, being made rigid by a large quantity of blood which is pumped into it by the heart, in order to cause its distension. The foot is an organ of locomotion, and is also used in burrowing. It is possible for Venus to creep about by means of its thrusting and wormlike movements; but I believe that the animal uses it in this way much less than is generally supposed, and this is a point of much interest to the clam culturist.

In order to understand the mechanism by means of which food is collected, it is necessary to describe in more detail the structure of gills and palps. The gills are the most complicated organs in the bodies of lamellibranchs, and must be described here as briefly and as simply as possible, without mentioning their wonderful histological structure. Outer and inner gills are practically the same. Suppose that one of these is carefully removed from its line of attachment to the body, and studied by means of the microscope from the surface and in section: such an examination shows the gill to be not a solid flap or fold, but an exquisitely minute basketlike structure with an outer and inner wall inclosing a space between. These walls are made

of extremely fine rods placed side by side, as represented in the most diagrammatic way possible in figure 3. In order that these rods, *r*, may retain their position, they are in many forms, irregularly fused with each other by secondary lateral growths of tissue, *ic*. The outer and inner walls of the gill are also held together by partitions which extend across the inner space between them, *p*. The gill is thus seen to be basketlike, the walls being made of rods between which are spaces, *s*, which put the interior chamber in communication with the mantle space in which the gills hang.

These rods, or filaments, of which the gill is made, contain an interior space in which the blood flows. They were probably primarily developed in order that the blood of the body might be brought in close contact with the water, that, by diffusion, the carbon dioxid of the blood might pass outward through the thin walls, while, by the same process, oxygen, carried by the water, might pass into the blood. But, in addition to performing the function of breathing, the gills have taken on that of collecting minute organisms used as food. This is accomplished by a complicated process.

We have seen that a constant stream of water entered the mantle or branchial chamber. What becomes of it? And what is it that causes the current? All of this water in the mantle chamber streams through the minute openings between the filaments of the gill and enters its interior space. It now rises to the base of the gill, and flows into a tube, the epibranchial chamber [*fig*. 1, *ec*], through which it passes backward, leaving the body by the upper or exhalent siphon, which is directly continuous with the epibranchial chambers of the four gills. The currents which we first noticed, then, enter the mantle chamber by the lower siphon, pass into the interiors of the four gills, flow to their upper or attached edges, and are directed backward and out through the upper siphon tubes of the mantle.

The cause of these rapid currents is revealed by a microscopic examination of the rods or filaments of the gills. These are found to be covered on their outer surfaces, which face the water on both sides of the gill, with innumerable short, hairlike structures which project perpendicularly from the surface. These cilia

are protrusions of the living protoplasm of the cells which form the walls of the filaments. Each possesses the power of movement, lashing in a definite direction, and recovering the original perpendicular position more slowly. This movement is so rapid that it can not be seen till nearly stopped by inducing the gradual death of the protoplasm. It is very effective in causing strong currents in the surrounding water.

A microscopic examination, and direct experiment with minute, floating particles, will show that other cilia are present on the filaments than those which cause the water to enter the gills. The diagrammatic figure of the gill [fig. 3] does not show why the minute food particles may not be taken into the interior of the gill by the entering stream of water, and finally out of the body through the broad water channels. This is prevented by long cilia arranged in bands which project out laterally between contiguous filaments in such a way as to *strain* the water which enters the gill, thus preventing all floating matter from entering. These highly specialized cilia tracts of lamellibranch gills, I have called the "straining lines."[1] In some forms there is a single line, in others there are two. In some cases the lines are formed by a single row of cells; or a section across the line sometimes reveals several closely crowded cells bearing the greatly elongated straining cilia.

That foreign matter is really excluded as the current of water enters the gill, may be demonstrated by direct experiment on a living gill. Carmine may be ground into a fine powder, and suspended in water without becoming dissolved. If a small amount of this is allowed to fall on the surface of a living gill, it will be seen to lodge there. A wonderful thing now occurs. A myriad of separate minute grains, which may represent the food of the clam, are almost instantly cemented together by a sticky mucus which is secreted by many special gland cells in the filaments, and the whole mass, impelled by the oscillations of the cilia, begins to move with some velocity toward the lower or free edge of the gill. On this free margin is a groove into which the material collected on the faces of the gill is turned.

1 Kellogg, J. L. Contribution to Our Knowledge of Morphology of Lamellibrauchiate Mollusks. U. S. Fish Com. Bul. 1892.

This groove is also lined by ciliated cells, and the whole mass is swept swiftly forward in it toward the palps. The natural food of the clam, of course, is carried forward in the same way. It is evident that a large proportion of the organisms floating in the water which enters the mantle chamber must come in contact with the sides of the gills, and be carried forward to the mouth folds, to which they may be transferred.

These points may be made more clear by referring to the diagram [fig. 4]. It represents a section made transversely across the filaments of a typical lamellibranch gill. In a single gill there are thousands of these rods. But five are shown here on each side, standing in row to form the perforated walls of the gill. Each rod is represented as being more or less oval, when its cut end is viewed in this way. In three places are shown the lateral union of filaments. The reference letters *ig* are supposed to be placed in the interior space of the gill, and *p* shows the nature of the partition, or septum, which, at more or less regular intervals, stretches across this space and holds the two walls of the gill together.

The details of cellular structure have been drawn in two filaments. The long, straining cilia, which stretch across the spaces between rods, are shown at *sc*, and the arrow indicates the course taken by the water current as it enters the interior of the gill. The cilia which cause this entering current are the frontal cilia, *fc*. Opening on the surface between them and the straining cilia are the gland cells, *gc*, the secretion from which cements together the food particles.

This figure is not intended to represent the details of structure found in the gill of Venus, which is much more complicated in many ways. The general plan of structure and of function in that form, however, is very much as represented, and this diagram is used because it may be so much more easily described.

If we now examine the palps with a hand lens, we may notice that their inner surfaces — those nearest to the mouth — are covered by a set of very fine parallel ridges. The lateral portions of the palps are shown in figure 2, *ap* and *pp*. They are capable of many movements. They may be bent and spirally twisted,

lengthened or shortened, and, if their inner faces touch the edges of the gills, any material which is being brought to this region is transferred onto the ridges of the palp. This is accomplished by strong cilia which are developed on the ridges. These same cilia carry the foreign matter on across the ridges, and finally force it into the mouth [arrow on *pp*].

This, in brief, is the method by which clams and oysters and other lamellibranchs collect and ingest their food. The process, till very recently, has not been closely studied, but this automatic feeding process has been known in a general way for a long time. It has sometimes been said that, if a lamellibranch is to prevent suspended mud from being collected by the gills, it must close its shell, thus entirely preventing all ingress of water into the body. It has been found that these creatures have no more control over the activities of the cilia which have been described than a man has over the cilia in his trachea. As long as the animals live, the cilia continue to lash in the same definite directions, though their activities soon become lessened after the shell is removed.

But I have found that the animal can prevent food or particles of dirt from being taken to the mouth while the stream of water is yet flowing. It seems never to have been suspected that complicated mechanisms existed, by means of which collected particles could at once be discharged from the body. They are present, however, probably in all lamellibranchs, differing somewhat in different forms, and I shall describe the comparatively simple one which is found in Venus.

If the mantle and gills are removed from one side of the body, so as to expose the visceral mass and the foot, and the creature is put into a dish of sea water, grains of carmine, which are allowed to settle on the surface of the visceral mass, at once indicate the presence of a ciliation there, as well as on palps and gills. These experiments require care and patience, but they show with great certainty that the most definite cilia currents exist in this region. These are indicated by the arrows placed on the visceral mass in figure 2. It will be seen that all the currents converge at a definite point, *x*, just above the line of the base of the muscular foot on the

posterior margin of the visceral mass. Any material, then, which touches this surface, instead of being taken toward the mouth, tends to be forced in the opposite direction. Immediately on touching the wall of the visceral mass, the fine particles are cemented together by an abundant mucus, as on the gills. When much carmine or mud is used, a large ball of it is collected at *x*. It will be noticed that this region lies directly in the path of the incoming stream of water from the branchial or lower siphon; and at first sight it would seem that from this position there could be no means by which it could escape from the mantle chamber. Clams undisturbed in the bottom, however, from time to time may be seen to discharge a strong jet of water from both siphons. This habit of many lamellibranchs is better shown in Mya. When these clams are kept in a bucket of water over night, the floor will be wet for many feet around it in the morning, and indeed one may at any time when they are so kept, see them violently close the shell by contracting the adductor muscles, thus emptying the mantle chamber by throwing a strong jet out of both siphons. This peculiar habit of all lamellibranchs which have been observed is, without doubt, for the purpose of removing masses of material which the animal can not use as food.

This is not the only means of discharging undesirable material from the mantle chamber. If the entire body be removed, leaving only the mantle lining the shell on one side, it also will be found to be ciliated. In this case, as illustrated in figure 5, everything is swept downward toward the free edge of the mantle, and falls into a line parallel with the edge, and is then directed backward. Particles which may fall on the extreme edge are also passed into this well marked stream. Everything is directed backward, but can not be carried out of the incurrent siphon against the stream which is entering through it. In a little bay beneath the base of the siphon, where it is out of the current, the material is collected. By the contraction of the adductor muscles, and the resulting emptying of the mantle chamber, as described above, this collected mass is expelled.

But, in spite of the activities of these two surfaces, which tend to rid the body of material not fit for food, it is evident that, if

much mud is entering, large quantities of it must be collected on the gills and be sent forward toward the mouth. I have spoken of the fact that the palps are capable of extended movements. If they are withdrawn so as not to touch the gills, material will accumulate in the anterior parts of the gill grooves till masses are formed so large that they fall off into the space of the mantle chamber below — perhaps to be taken up by the currents on the mantle. At any rate, they would be discharged when the mantle space was emptied. I have no doubt, especially after what I have observed in forms like Yoldia, that the palps of Venus are from time to time withdrawn from contact with the gills, in order that they may receive no material from them.

It is when we come to examine the palps that we find the most complex arrangement for keeping material from entering the mouth when that is desirable. A close examination of the inner faces of the palp shows a narrow strip around its margin which is without the ridges previously described. Both of these margins are very densely ciliated. When suspended material falls on the upper margin, it is carried up onto the surface of the ridges [fig. 2, *um*] and across them to the mouth. Anything which touches the other margin, on the other hand, is swept with great rapidity in the other direction — out to the end of the palp, where it accumulates and is finally thrown off into the mantle chamber below. It is true that this margin is narrow, and not much material suspended in the water would strike it; but probably when a large quantity is collected on other parts of the palp, this edge is folded over so as to touch these heavily laden surfaces, and sweeps them clean.

It thus appears that there are extensive ciliary tracts for collecting and conveying food to the mouth; but that, in addition to these, there are other ciliated surfaces by means of which undesirable material may be excluded without the necessity of closing the shell. Because of the advantage of sustaining the aeration of the blood, this must be of very great service when the water is muddy.

In this description of the feeding habits of Venus many important details have been omitted, particularly in regard to the

anatomy of the gill, which is much more complicated than is indicated in the figures.

The question of food is an important one when we are searching for means of rearing this clam by some culture method. In order to force the growth of oysters in French *claires*, water is held in reservoirs back of the beds till the contained diatoms may have multiplied greatly, and is then allowed to run over the beds. Such methods are expensive, and under proper natural conditions, Venus will grow very much faster than either the European or American oyster. Enough has been said of the food of Venus to make it clear that, if it were raised on beaches or flats, we should not expect to find so rapid a growth as if it were never exposed, for feeding is impossible without water currents. I hope to show, however, that growth seems to be very rapid even under these circumstances.

Growth experiments

Before speaking of these experiments, it will be well to make it clear that the planting was done on a small scale, and was pursued under the most adverse circumstances. I believe that the results as we have them are perfectly certain — and they are most satisfactory as they are; but I am also sure that under favorable conditions growth would have been very much greater.

A trip was made to Riverhead, and the shore examined carefully as far as Greenport. Many clams are found along this shore, and several sites were located, which, so far as currents and character of bottom were concerned, seemed to be ideal. In every case, however, I was assured that clams would not be allowed to remain unmolested for a week. So certain did this seem, that the very much less favorable harbor at Cold Spring, on the sound, was selected. Here also it appeared that no portion of any of the beaches would be free from molestation by clam-diggers. The only thing to be done was to ask the privilege of a small space on an oyster bed which extended close to the low water mark. This was granted by Captain Jones, who has my sincere thanks for this favor, and also for the kindly interest which he showed in the work.

The rights of the oystermen seem to be strictly respected. I ventured to run some of my beds up on the narrow beach nearly

to the high tide line, marking them by labeled wires which were run down out of sight. These I easily found in the winter, but some of the beds had been raked clean. Others certainly escaped observation. Before planting, the ground was raked, that I might be assured that no little-neck clams were present in it. I am very positive that the beds and sealed wire cages on the oyster ground had not been touched when they were examined after an interval of six months.

But the unfavorable conditions were these. Everywhere above and below these beds, oysters covered the bottoms as close as they could lie. They take from the water the same floating organisms which Venus uses for its food. Everywhere, too, above and below low tide line, soft clams were burrowed almost as close as they could be placed. They also use the same food. Now, we have experimental evidence to show that the growth of all these forms is, up to a certain point, directly proportionate to the amount of food. They all grew here; for, on account of the conditions of the upper harbor, where at high tide the shallow water, fed by fresh-water streams, was warmed for hours by the sun, diatoms must have multiplied with great rapidity, and, when carried out, offered abundant food. But undoubtedly none of these lamellibranchs grew as they would if the life of the bottom had not been so abundant.

As an example of the number of these organisms on the bottom, this case may be cited. A flowerpot, 4 inches across the top, filled with clean sand, was sunk nearly to the level of the ground on June 19, 1901. In it was placed a little-neck clam. When examined Dec. 28 of the same year—six months afterward—the sand in this pot contained 11 soft-shelled clams ranging from half to three quarters of an inch in length, besides the hard clam, which had increased considerably in size. These soft clams had settled in the pot from the swimming larval condition, as they settled elsewhere on the bottom, and had begun to grow. It is most reasonable to suppose that, if this hard clam had been growing on almost any beach where less life was being supported, its growth would have been more rapid, for diatoms are more or less abundant all along the shore.

Another serious hindrance to the growth of clams is the presence of the seaweeds, Ulva (sea lettuce) and Enteromorpha which, during the greater part of the year, grow profusely after their attachment to large pebbles or other solid bodies on the bottom. Not only the larger stones on these beds, but, especially, the wire cages which were sunk into the bottom, were in December more or less completely covered by them. In extended experiments on the growth of the soft clam, Mya, the same difficulty was met with in many localities. The masses of weed, flattened out on the bottom by the tide currents, greatly hinder the clams underneath from obtaining from the water their needed food. My experiments with both forms show that this condition is detrimental to the best results. If one were free to select sandy ground which would afford no means of attachment, this difficulty would not appear.

These matters are spoken of in detail because the results which will be given should, without doubt, have been far greater. Any one with rights to certain parts of a beach, who could watch his beds at all times of the year, could, with very little labor, prevent these drawbacks.

Still another difficulty attending the work at Cold Spring was the fact that it was almost impossible to obtain clams small enough for planting. None were to be had in this locality. A number were sent from Jamesport, L. I., but most of them were of marketable size, and hence too large for the most important part of the experiment. The smaller ones came from New Bedford Mass., and these had perhaps previously been received from Edgartown. It must however be said that the hard clam, like the oyster and quite unlike the soft clam, Mya, will live for many days, and even for weeks, after being removed from the water during the hot summer time, without apparent injury. The soft clam may be preserved in this way for a long time during the winter, and very small individuals may safely stand much exposure in hot weather; but the larger forms of this species succumb after a short time. The tenacity of life in the small Venus may also be greater than in the adult, but nothing is known in regard to it.

Methods

Each clam was measured in sixteenths of an inch at the time of planting, and also when taken from the bottom six months afterward. Merely to state the increase in length, however, gives no adequate idea of the actual growth. It is much better to give the increase in volume. To state that a clam increases from $1\frac{2}{16}$ to $1\frac{12}{16}$ inches in a certain time gives little idea of its actual growth. If individuals of the two sizes are held in the hand and compared by the eye, the bulk of one is seen to be much greater than that of the other. It is really this increase in volume which we wish to determine, so each clam was measured also by determining its displacement in water. A table was made showing the displacement of clams of various sizes. For example, many individuals just 1 inch in length were measured in a graduated vessel. There is some slight variation, because some are thicker than others. The average of many measurements, however, shows that a clam of this length displaces 2.5 c.cm. The average displacement of other sizes was determined in the same way.

To illustrate the difference in the two ways of stating the increase, we may compare clams 1 and 2 inches in length. One is 100% longer than the other. One has a volume of 2.5 c.cm, the other a volume of 22 c.cm; and, while a clam 1 inch long has increased in length 100%, it has increased in bulk or volume 780%. This increase in size or volume is what we wish to determine.

Suppose that in a certain bed are placed clams all of a size. When these are dug, after a lapse of several months, some individuals will have increased in size more than others, though the differences may not be great. In order to determine the increase in such a bed, the arithmetical mean length of the whole series has been calculated, and the volume of the mean has been compared with the volume of the clams when planted.

In one bed, for example, several clams $1\frac{3}{16}$ inches in length were planted. In six months they were removed, and the length of each individual carefully measured. There was some individual variation in the length; so the mean length of the series was calculated. It was found to be $1\frac{12}{16}$ inches. The average volume of clams $1\frac{3}{16}$ inches long is 4.5 c.cm; that of individuals $1\frac{12}{16}$ inches long is

14.5 c.cm, or 3.22 times as great. The increase in volume in the six months, therefore, was 222%.

Growth between tide lines

The most important point brought out in this experiment is the fact that growth is considerable on bottoms exposed for several hours at low tide. This is shown in the following cases.

A line of flowerpots was run from below ordinary low water mark up the steeply sloping beach to a point about two feet below the ordinary high water line, the fall of the tide being about six feet. The pots were sunk so that their tops were level with the ground, and were separated by a space of about two feet. June 19, 1901, there was placed in each of these pots a clam 1.25 inches, or — to give the measurements for convenience's sake in sixteenths of one inch — $1\frac{4}{16}$ inches in length. These were examined, after an interval of six months, on Dec. 28. Some of the pots were empty or contained dead shells. In the first or highest, the clam had grown to a length of $1\frac{11}{16}$ inches, an increase of 148% in volume in the half year. If we had no other example of growth, this would be very suggestive, for the increase is great, the creature having become in this short period almost two and a half times as large as when planted.

We should expect to find still greater growth with longer immersion. In the second pot, the clam had increased 154%, and in the third, still lower down, 172%.

The fourth pot was empty. In the fifth, the increase, instead of being greater still, was only 87%. The explanation of this seems to be perfectly clear, and is exemplified in several other cases. Around the margin of this pot there had grown a large quantity of Ulva. There was much of it at this level of the beach, while higher up it was not abundant. Without doubt this seaweed was flattened out over the top of the pot by the current, in such a way as to prevent free access to the food-bearing stream, and for this reason growth was not so rapid.

The presence of these weeds, which grow on so many bottoms, should not seriously inconvenience the clam culturist. They may be removed without difficulty with a rake, and do not grow abundantly on a surface which is reasonably smooth. If it had

been possible to visit these beds a few times during the summer, the results in the case of many lower beds would undoubtedly have been different.

In pots still lower down, all of which were covered with Ulva, the growth was much the same as in the fifth — from 80% to 100% increase.

In this line of pots, then, the fact is demonstrated that between tide lines, hard clams 1.25 inches long may increase 2.5 times or more in volume in half a year. Localities more favorable for their growth could easily be found. If experiments were made on a large scale, I should expect to get a more rapid average growth even where the forms were exposed at low tide, and a much greater increase on bottoms which are never exposed. As it is, this growth as compared with that of the oyster is marvelously rapid, just as it is in the soft clam.

It should be noticed that we are not attempting to make extended generalizations on the data given by four or five individual clams. Two clams side by side will not increase at the same rate. It is possible that one might grow twice as fast as another. But, if we had a single case in which we were certain of the amount of increase, it would assuredly indicate the possibilities of growth, and the chances are that it would not by any means be the limit of possibility.

On the other hand, when we compare the growth in pots 1, 2 and 3, and find a progressive increase from the higher to the lower pot — an increase of 145%, 154% and 172% — our induction is founded on insufficient data, and really means nothing. The result is as we should expect it, but it may be entirely accidental. But it is suggestive, and, if it were possible to observe many rows of clams similarly placed, we might reasonably expect to establish it. Unfortunately it has not been possible to do this.

The simple case of the line of flowerpots has been spoken of first because it was more or less typical of the results obtained in many small beds planted under similar conditions. Many hundreds of clams, after being carefully measured, were segregated into groups according to length and planted together. Their growth substantiates the results obtained in the flowerpots.

Very briefly the following results will be described. Several small beds, each with an area of 16 square feet, were laid out on the gravel between tide lines. A group of these was separated by an interval of 20 or 30 yards from another group. Most of these small plots were within the boundaries of the oyster bed already mentioned, but some were above the line of the bed, and a few of them were dug clean. Others were not discovered by clam diggers, and apparently entirely escaped molestation.

In each of these small beds, clams all of a size were planted. The number on a bed varied from 100 to 175. I would call particular attention to the fact that on the deeper beds, where the tide currents were swiftest, larger stones were exposed, and there was here an abundant growth of seaweed, which was not found farther up on the beach. This always interfered seriously with the growth of the clams.

For example, on these beds which were below the ordinary low tide line, where we should expect to find the most rapid growth, there was an increase in volume in clams $1\frac{12}{16}$ inches long, of 35%; in those $1\frac{4}{16}$ inches long, of 41%; and in those $1\frac{10}{16}$ inches long of 42%. I am all the more certain that this low rate of growth is to be explained by the presence of the seaweed, because I had previously had the same experience in a much larger experiment in the soft clam. Fortunately, as I have already stated, a little labor by one who is able to be on the spot during the entire year would prevent this result.

Some of the higher beds, however, which from the character of the bottom were free from the weed, gave different results, and show the possibilities of growth much better. On a bed only three or four feet from ordinary high water line, there was placed on July 6, 130 clams, $1\frac{4}{16}$ inches long. On Dec. 30, almost the entire number was removed. Some had increased more than others. The mean of the series was calculated, and showed an increase of 255% in volume in a little less than six months.

On another bed, somewhat lower, 150 clams $1\frac{6}{16}$ inches long had increased 157% in volume. One of the things to be expected is that clams of smaller size would show a relatively greater growth. It has not been possible to make comparisons to demonstrate this

because of the influence of the seaweed on so many beds. The variation in the size of planted clams in this experiment was from $1\frac{2}{16}$ inches to $1\frac{12}{16}$ inches in length, and this is not a very great range.

On a third bed, also situated well up on the beach, clams $1\frac{8}{16}$ inches long when planted had increased 155% in volume in the six months. Whether the amount of food in the summer is greater than in the winter, I do not know. I have no doubt that the increase goes on during the winter months, though, it may be, with diminished rapidity. It would be extremely interesting to carry out these experiments on a large scale through the entire year. These facts certainly show that the possibilities of growth in Venus are very great, and indicate that its artificial culture between tide lines would be easy and inexpensive, and that it would yield large results. Considering the place which the little-neck has in the markets, it would seem that the artificial culture of the form should yield a larger income than does the culture of the oyster as carried on in Long Island sound. The latter is expensive and laborious, and growth is very much slower than in the case of either of the clams.

Wandering habits of Venus

The soft or long-neck clam, Mya, is capable of locomotion only when very small. As the body increases in size, the foot, or locomotor organ, becomes relatively smaller. An individual 2 inches long, while it can not move along the surface of the bottom, is still able to use the foot as a burrowing organ. When it has attained a length of 3 or more inches, however, it seems to be incapable even of covering itself in the bottom.

In the case of the hard clam, Venus, on the contrary, the foot remains throughout life a very well developed locomotor organ. Though no definite experiments have been made to demonstrate what it is able to do, one might assume, from the size of the organ and its power of extension as demonstrated in aquaria, that the animal is able at all times in its life, not only to burrow but also to move from one locality to another, as the fresh-water clams, with a similar foot, are known to do.

The beds in this experiment were planted with the fear that the clams would wander. The result, however, showed conclusively that they do not have this habit — or that they did not exhibit it in this particular case. The clams were found where they were placed within the limits of the original beds. Careful digging around the margins of the beds failed in every instance to show any wandering tendencies.

Growth under wire netting

In order to be perfectly certain that clams should have no means of escape, three cages of wire netting were constructed, bounding the margins of the area containing clams in each case to a depth of 5 inches and covering the top. These forms never burrow to a greater depth than this, and there was no possibility of escape. In each case the netting remained intact, and certainly was not disturbed. These beds were exposed only during the full moon tides. Here also the seaweed seemed to play an important part in the results. In one case the netting was sunk so deep as to be covered with sand, and consequently no seaweed attached, as it did on the other cages. Growth was much more rapid here, though the clams in this bed were smaller when planted, and, as a consequence, a more rapid growth should have been expected.

The results were as follows:

Cage 1 Clams planted July 6, $1\frac{8}{16}$ inches long. Some seaweed was attached to the wire of the cage. The clams were removed Dec. 30. The increase in volume was 145%.

Cage 2 Planted July 6, $1\frac{6}{16}$ inches in length. Removed Dec. 30. A very large quantity of weed over the cage. Increase in volume, 78%.

Cage 3 Planted July 6, $1\frac{4}{16}$ inches long. This cage was sunk so deep that no weed was attached on the surface. The increase Dec. 30 was 222% in volume in the six months.

Growth above the bottom

In methods of oyster culture as developed in France, the forms are placed in racks above the bottom, and from the tide which sweeps over them, they are enabled to obtain nourishment enough for comparatively rapid growth. It would be an interesting

thing to show that clams could be made to grow in this way. The clam culturist could then make himself independent of beach rights, and perhaps more easily obtain a lease of ground for such a purpose below low water mark.

But one or two very small experiments on the soft clam have indicated that the creatures do not do well under these conditions. At Cold Spring a wire rack was constructed, and anchored above the bottom in a swift current. Into it were put several hard clams ranging from $1\frac{4}{16}$ to $2\frac{12}{16}$ inches in length. Every one of these seemed to be in a healthy condition at the end of six months, but not one had increased a particle in size. Not being able to cover the body in sand, they seem to have remained most of the time with valves closed. They may possibly have moved about at times, for their shells were worn, but more likely this was due to the fact that they were rolled about in the cage by the currents. On their smooth, clean surfaces numbers of Anomias, or silver shells, had attached and grown, as shown in figure 6.

Though this small attempt to induce growth above the bottom ended in failure, it should, on account of its importance, be repeated on a large scale under as many different conditions as possible, in the hope that some combination of circumstances might prove to be the right one.

Enemies

Neither of the clams is molested by the starfish after it has become large enough to burrow, though the very small soft clam, and perhaps the hard clam also, is destroyed in great numbers by small starfish, before it is able to cover itself. So far as I have been able to discover, there is but one natural enemy of Venus which might possibly be destructive. It is the gastropod mollusk, Lunatia [fig. 7], which is abundant in some localities. It is found in numbers at Cold Spring. On several occasions I have observed it digging below the surface and attacking both hard and soft clams in their burrows. By long continued labor, it files a smooth, clean hole through the shell of its victim by means of a rasping organ in its mouth cavity, and then destroys the soft parts of the body within. Figure 8 illustrates the character of the borings on shells

taken from the beds at Cold Spring. In every case the perforation is near the prominence of the shell called the umbo, directly over the pulpy visceral mass, which might most easily be sucked up through the opening. It is a curious fact that this region of the shell is selected by Lunatia for boring in any lamellibranch which it attacks. It may not invariably be so, but I have many shells of different species which have been drilled in this region, and have happened to notice no exceptions to it.

No matter how numerous it might be, this enemy would probably not be as troublesome to clam culture as the starfish is to the oyster industry. In several places I have seen it collected by fishermen for bait, simply by pegging a bit of fish, or even a dead starfish on the bottom. In a short time numbers of them will be found collected on the bait. By some such simple means, if it were desirable, a clam bed probably could easily be rid of the creatures.

Conclusion

This experiment on the growth of Venus from lack of means and time and favorable locality has been a limited one. In order fully to demonstrate the feasibility of the artificial culture of the form, it should be carried out on a very much larger scale, and should be extended through a longer period of time. There can be no doubt about the accuracy of the results in the case of the wire cages, the growth in which has been described; and, from their position, I have no reason to think that the clams were disturbed on the other beds which have been cited as examples of growth. Some of the higher beds seem to have been discovered by clammers, and these were raked clean.

The figures giving the percentages of growth, though not numerous, at least indicate the fact that the most essential feature of the culture of the little-neck clam — rapidity of growth — is all that could be desired. Neither has anything appeared which would suggest a natural difficulty in the way of artificial culture.

DESCRIPTION OF FIGURES

Figure 1

Side view of large *Venus mercenaria*. Mantle fold on right side of the body has been removed. The edge of the left fold of the mantle is shown at *m*. The exhalent, *ex. s*, and inhalent, *in. s*, siphons are modified parts of the mantle.

Water bearing food and other floating substances enters the space between the mantle folds — the mantle chamber — through the inhalent siphon. Hanging in this chamber are the foot, *f*, and gills, *og* and *ig*. Cilia on the gills cause water to enter them, forcing it to their bases, into the epibranchial chambers, *cc*, and then backward and out of the body through the excurrent siphon. This is indicated by fine, dotted arrows. The two large transverse muscles — the anterior and posterior adductors — which, by their contraction, close the valves of the shell, are shown at *aa* and *pa*.

Reference letters: *aa*, anterior adductor muscle; *pa*, posterior adductor muscle; *cc*, epibranchial chamber; *og* and *ig*, outer and inner gills; *ap* and *pp*, anterior and posterior palps; *ex. s* and *in. s*, exhalent and inhalent siphons; *f*, foot; *m*, edge of left mantle fold; *s*, ventral margin of shell.

Figure 2

Drawn to show that floating particles which touch the surface of the visceral mass are taken posteriorly and thrown off into the mantle chamber at x. From this region, they are removed from the body by the contraction of the adductor muscles, which discharges a large part of the water in the mantle chamber.

At *pp* is shown the striation of the inner side of the posterior palp, over which food is taken to the mouth. The unstriated margin is also shown.

Other reference letters as in figure 1.

Figure 3

Paper model of lamellibranch gill. A diagrammatic figure to show the basketlike structure of the gill.

Reference letters: *ic*, interfilamentar connections; *p*, partition or septum holding the two halves of the gill together; *r*, a rod or filament; *s*, space between filaments.

Figure 4

Diagrammatic section across the filaments of a typical gill. Arrows represent the course taken by water which enters the gill. Reference letters: *ig*, interior of gill; *p*, septum between sides; *gc*, gland cells, the secretion from which cements floating particles into a mass on the outer surfaces of the gill; *fc*, fine frontal cilia causing water to enter gill; *sc*, straining cilia preventing solid matter from entering the gill and moving it to the ventral margin.

Figure 5

View of inner surface of left mantle fold of Venus, showing course taken by particles which touch it. These are discharged from the body when the stream entering the mantle chamber through the lower siphon is reversed by contraction of adductor muscles.

Figure 6

Hard clams kept in wire cage above the bottom for six months. All shells were covered by attached Anomia, or silver shells.

Figure 7

Lunatia, a gastropod mollusk, which bores shells and destroys clams.

Figure 8

Venus shells bored by Lunatia.

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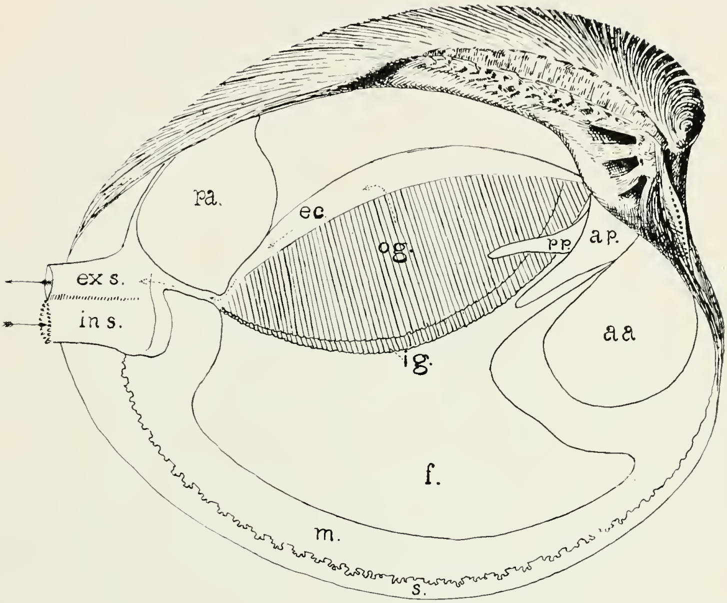
(*Pages 29–30 were bulletin cover pages.*)

Figure 1



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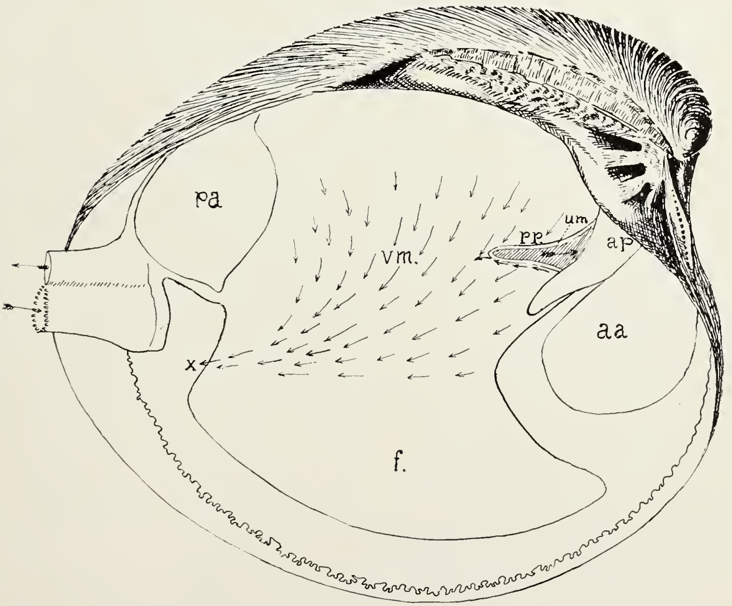

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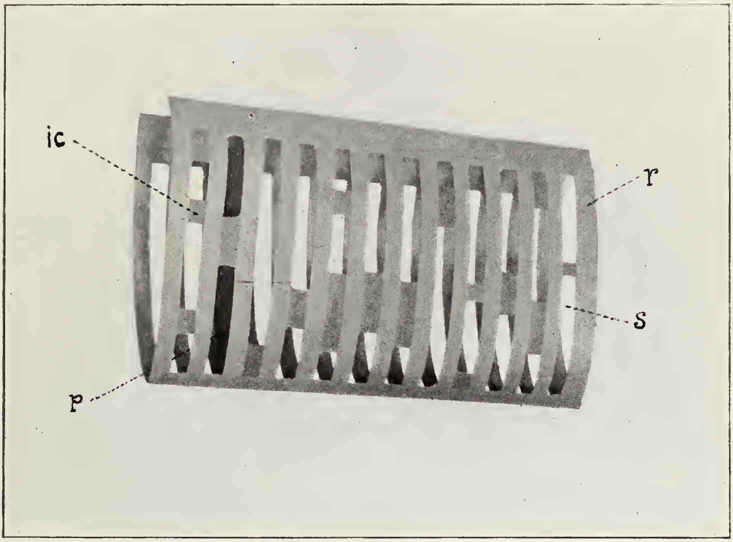

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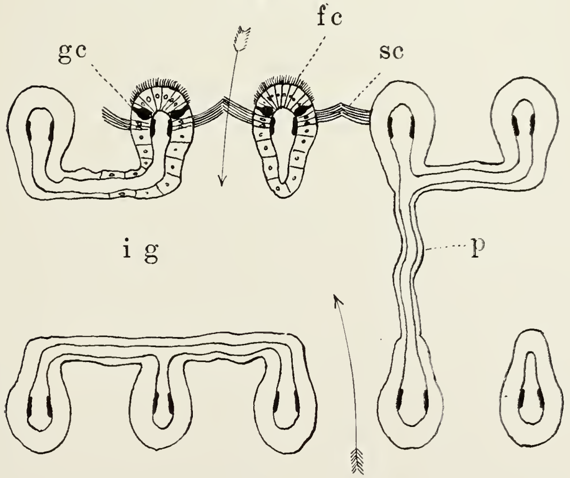

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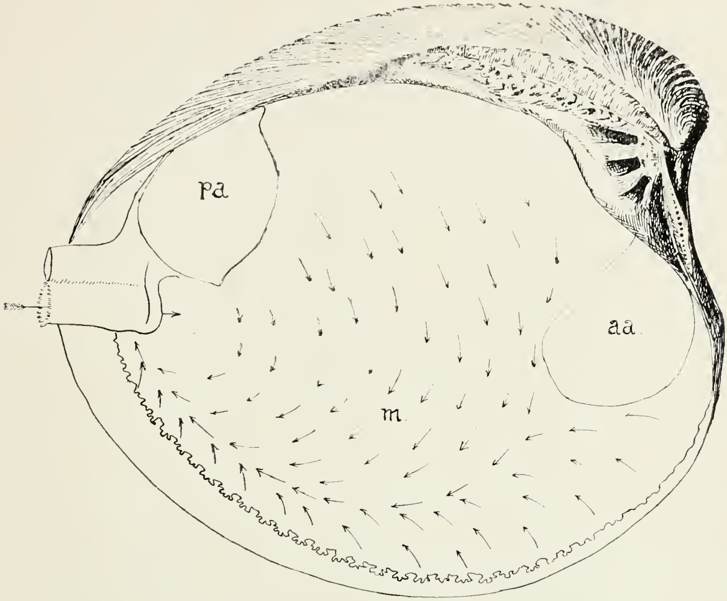


Figure 6

Figure 7

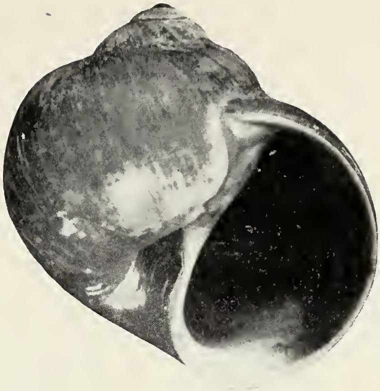
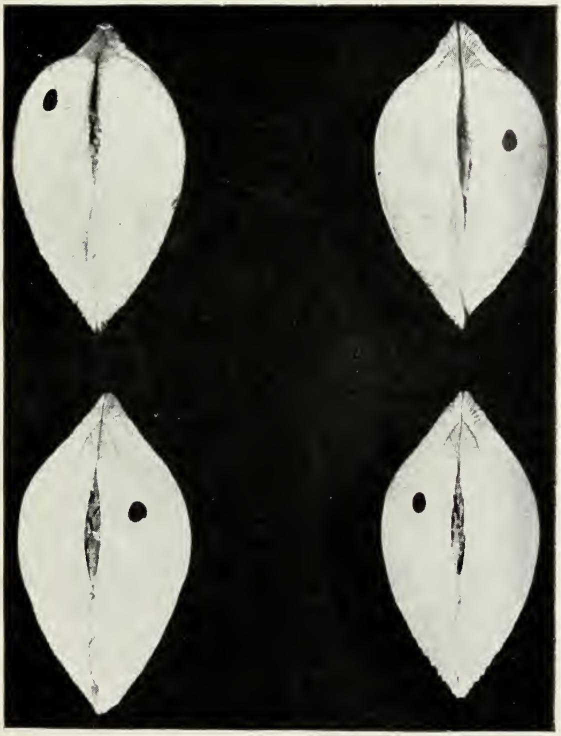


Figure 8



Map of the State of New York showing the location of its economic deposits